A CAHNERS PUBLICATION INTERNATIONAL EDITION MAY 28, 1987

EDN

EDN's Hands-On SMT Project—Part 1

Board-mountable circuit protectors

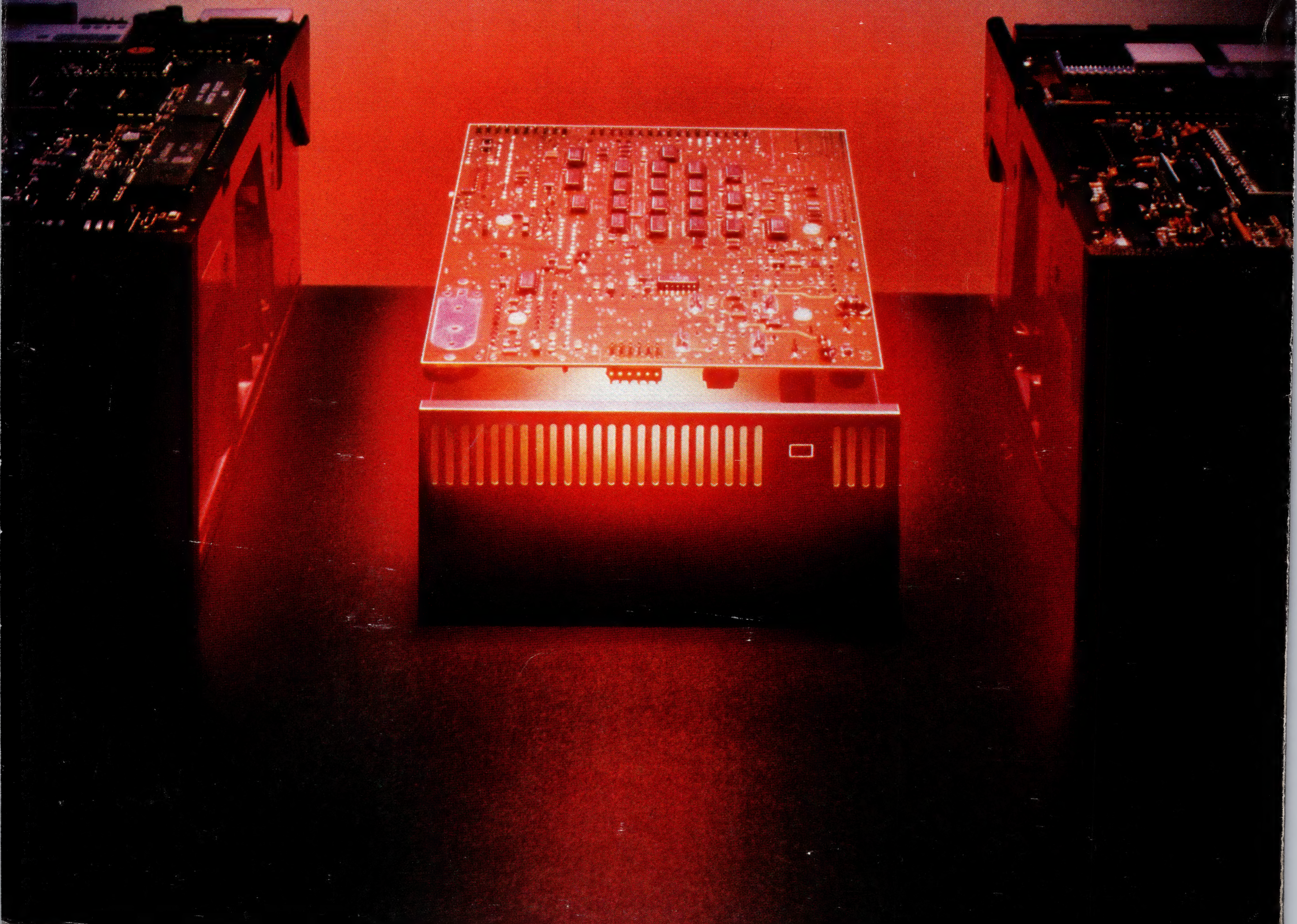
27 JUL REC'D

Silicon sensors

Math software for personal computers

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

Compact Winchesters offer embedded-SCSI power



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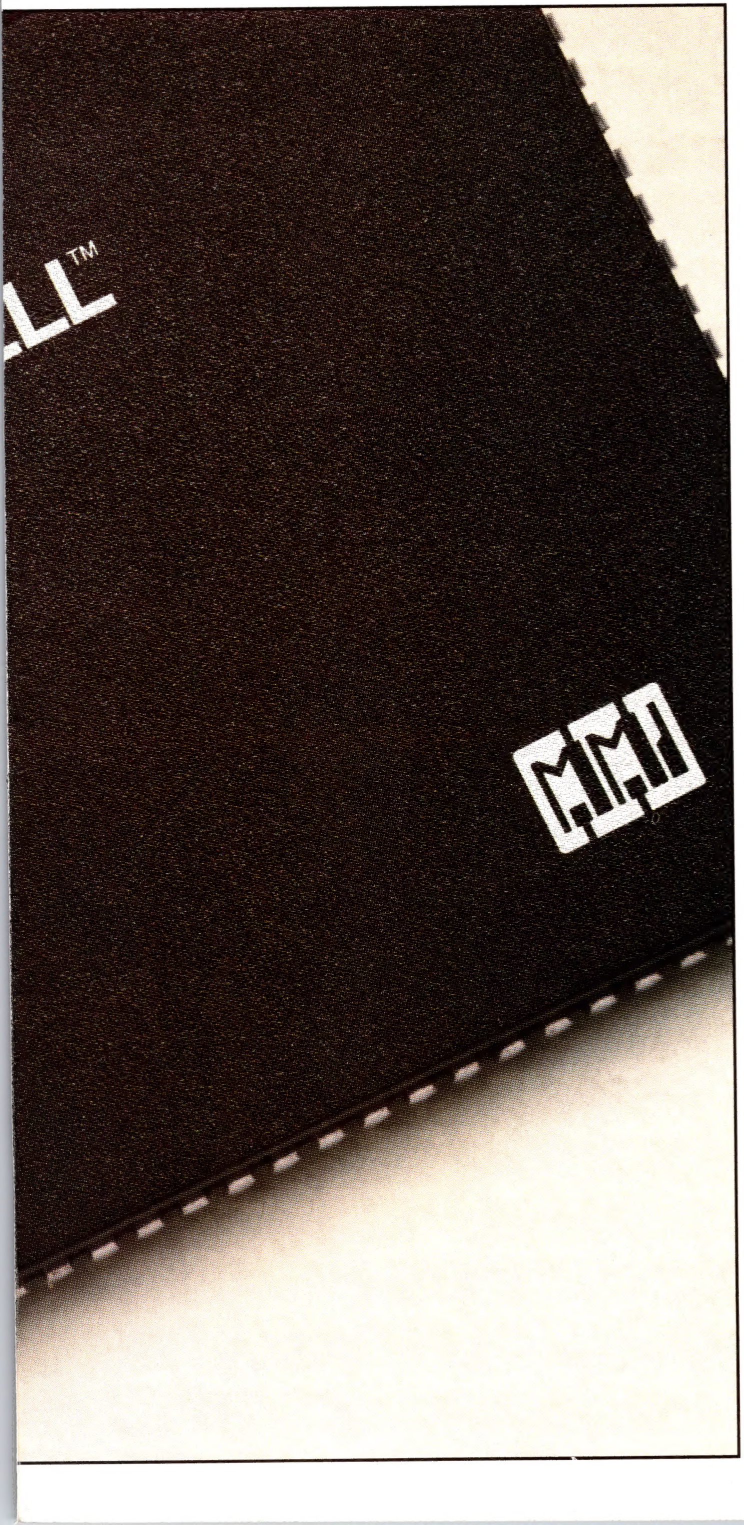

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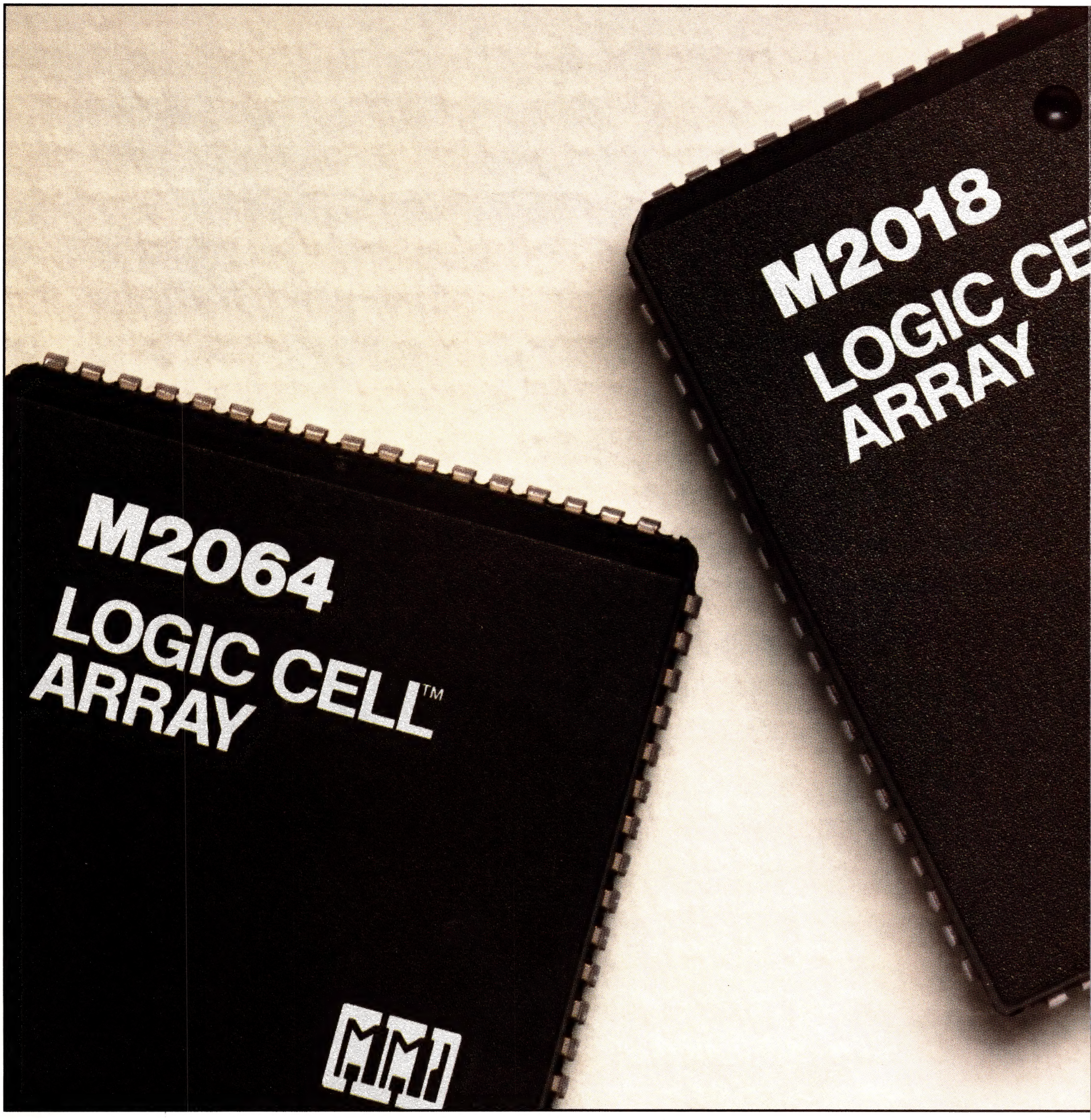
CIRCLE NO 76

Programmable gate arrays, what else?



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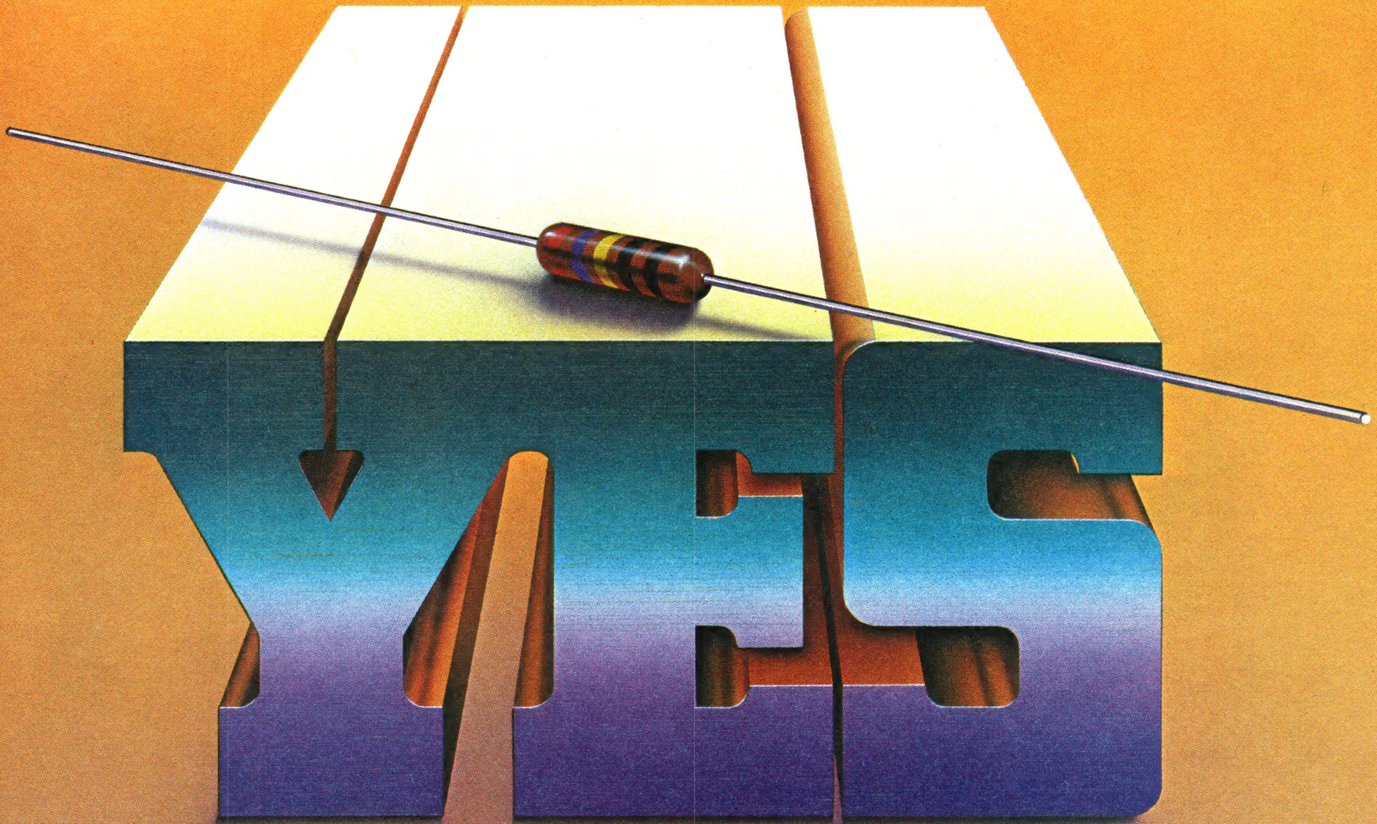

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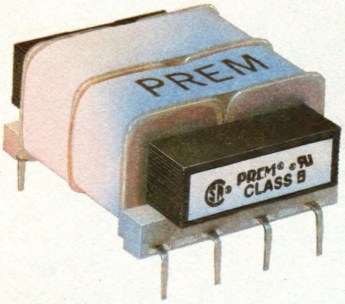

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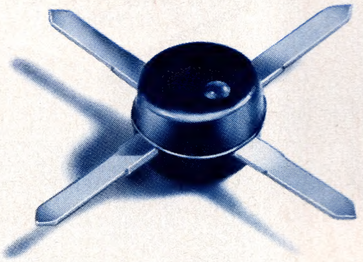

dc to 2000 MHz amplifier series

SPECIFICATIONS

Model	Frequency MHz	Gain, dB (min.)	Max. Power dBm (typ)	NF dB (typ)	Price $ Ea.	Qty.
MAR-1	DC-1000	13	0	5.0	0.99	(100)
MAR-2	DC-2000	8.5	+3	6.5	1.50	(25)
MAR-3	DC-2000	8	+8	6.0	1.70	(25)
MAR-4	DC-1000	7	+11	7.0	1.90	(25)
MAR-7	DC-2000	8.5	+4	5.0	1.90	(25)
MAR-8	DC-1000	21	+10	3.5	2.20	(25)

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80 × 50	10%	X7R	2200, 4700, 6800, 10,000 pf
120 × 60	10%	X7R	.022, .047, .068, .1µf

* MINIMUM ORDER 50 PER VALUE

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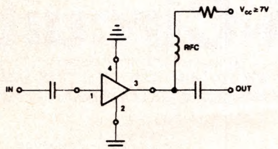

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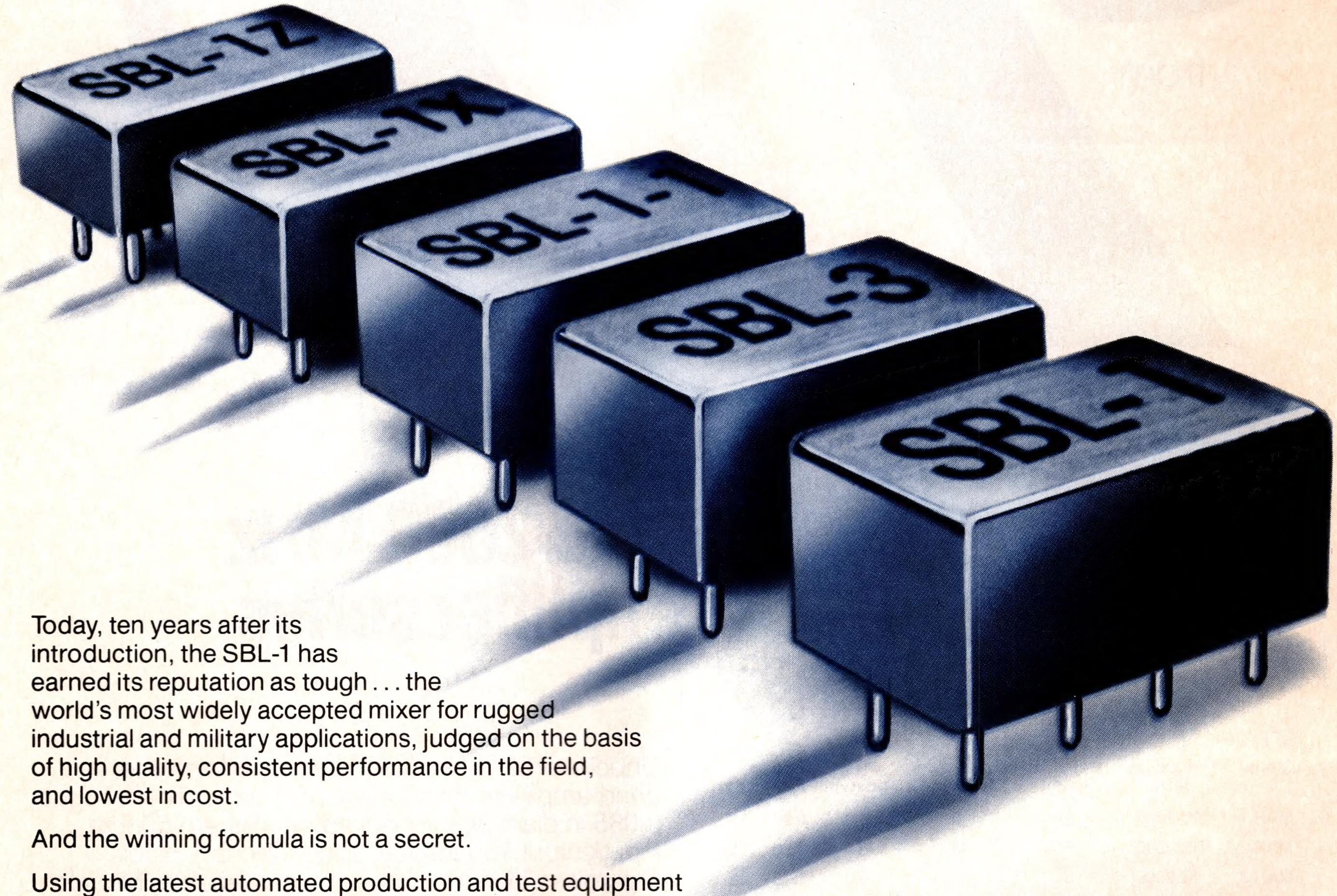
C113 REV. B

CIRCLE NO 158

more tough mixers



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SBL-1Z	10-1000	6.5	35	25	**$6.95**
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* If not DC coupled.

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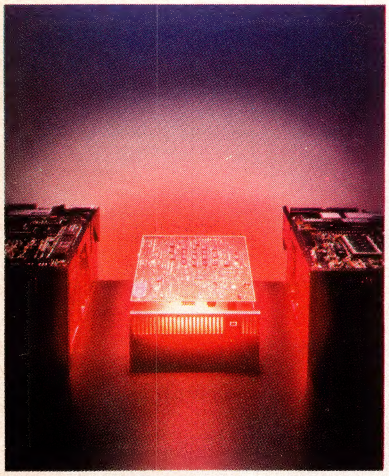
Volume 32, Number 11

EDN

May 28, 1987

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



On the cover: *Embedded-SCSI Winchester disk drives are a feasible alternative to drives with device-level interfaces. See pg 134. (Photo courtesy Maxtor)*

DESIGN FEATURES

Special Report: Embedded-SCSI Winchesters 134

The SCSI intelligent I/O bus permits the use of a wide variety of disk drives and other peripherals in minicomputer and microcomputer systems. By offering improved performance at reasonable prices, embedded-SCSI Winchesters make it easier than ever to implement the SCSI bus in your designs.—*Maury Wright, Regional Editor*

EDN's Hands-On SMT Project—Part 1 164

EDN set out to convert an existing through-hole pc board into a version populated by surface-mount devices. The challenges we faced while designing the SMT version and supervising its fabrication and test illustrate the problems you might encounter when pursuing SMT's benefits. This 5-part series chronicles this 18-month project.—*Steven H Leibson, Regional Editor*

Cache accelerates operation of 32-bit μP systems 183

As you move up from 16-bit μP-based designs to 32-bit systems, you'll find it especially critical for your microprocessor to have access to high-speed memory.—*Robert Nalesnik, Fairchild Europe Semiconductor*

Shift-register applications reach gigahertz range 195

Applications that employ shift registers would hardly turn their backs on higher-speed devices, and GaAs-based parts that can achieve gigahertz clock rates are starting to appear. When those parts incorporate an on-chip XNOR gate for pseudorandom-number generation, they extend the range of shift-register applications.—*Panos Argyroudis and John Schaefer, GigaBit Logic*

XOR PLDs simplify design of counters and other devices 205

XOR PLDs' unique architecture is better suited than that of conventional AND-OR PLDs to certain applications. Once you understand the basic theory behind their operation, you can easily configure them to perform the tasks of such devices as binary counters and video shift registers.—*Chris Jay, Monolithic Memories Inc*

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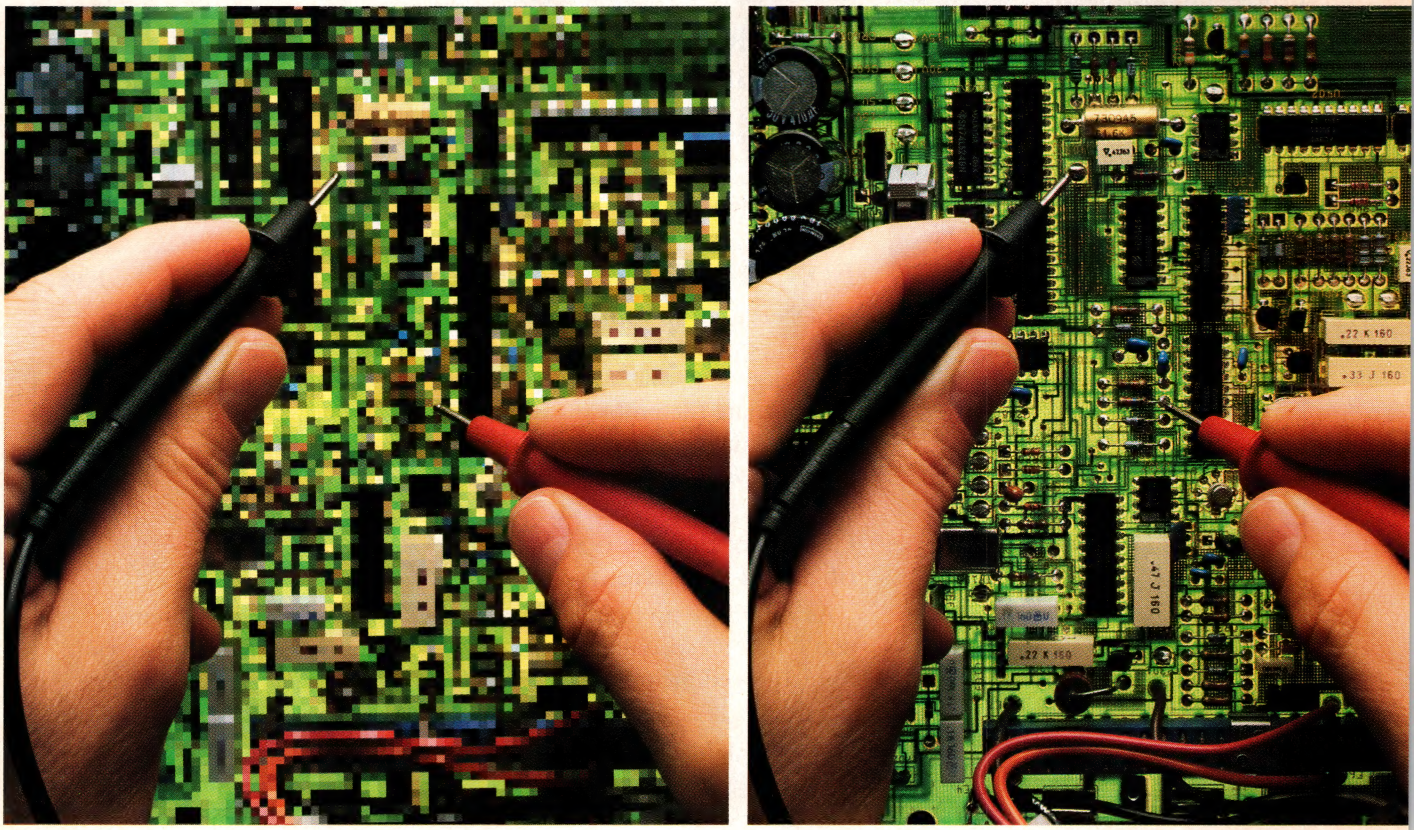

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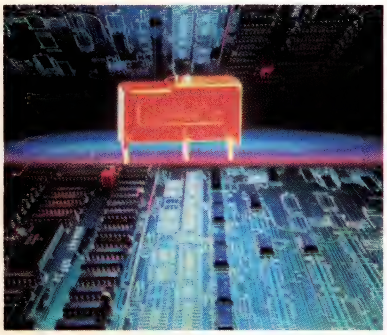

***Board-level protection** keeps your circuits out of trouble (pg 65).*

TECHNOLOGY UPDATE

Today's circuit-protection devices provide needed board-level surveillance 65

As pc boards continue to increase in circuit density and complexity, designers have an ever-increasing need to include circuit protection right on the boards themselves.—*Tom Ormond, Senior Editor*

Smaller, cheaper silicon pressure sensors are starting to appear on vendors' shelves 83

Steady advances in the manufacture of silicon-based sensor ICs have enabled vendors to produce smaller parts, and bulk production has led to dramatically lower prices.—*Chris Everett, Regional Editor*

Sophisticated mathematical software now runs on workstations and personal computers 95

Whatever your involvement with applied mathematics, you'll almost certainly be able to find a software package that can help solve your mathematical and engineering problems and that runs on your workstation or personal computer.—*Chris Terry, Associate Editor*

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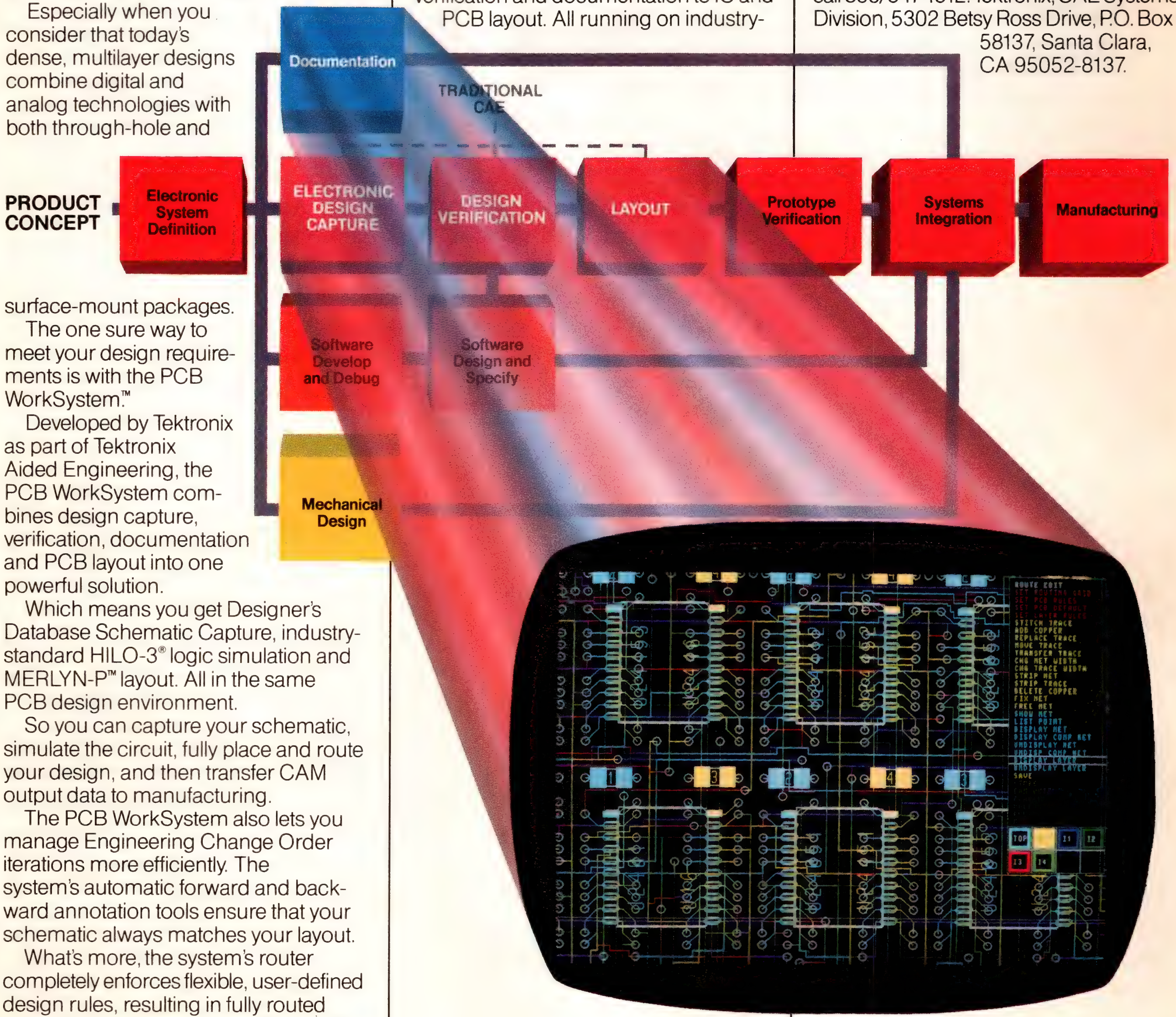

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Don't be afraid of surface-mount technology. You can be sure that your competitors aren't.

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IMS1620 (x4)	35, 45, 55ns
IMS1624 (OE, x4)	35, 45, 55ns
IMS1630 (x8)	45, 55, 70ns

LOW POWER DATA RETENTION CMOS SRAMs		
Device	Access Times	Idr*
IMS1403L (x1)	25, 35, 45ns	0.5μA
IMS1601L (x1)	45, 55, 70ns	10μA
IMS1620L (x4)	45, 55, 70ns	10μA
IMS1624L (OE, x4)	45, 55, 70ns	10μA

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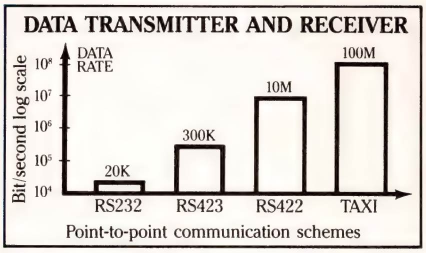
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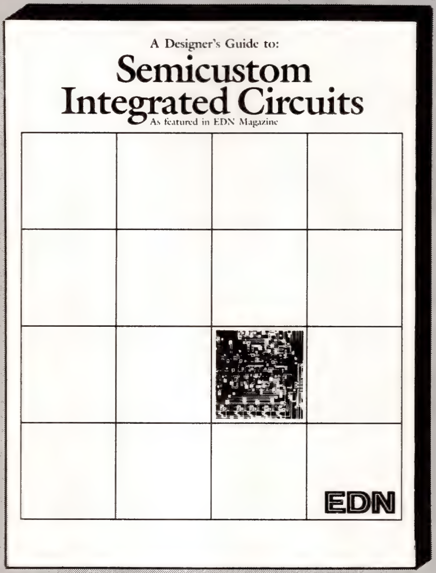

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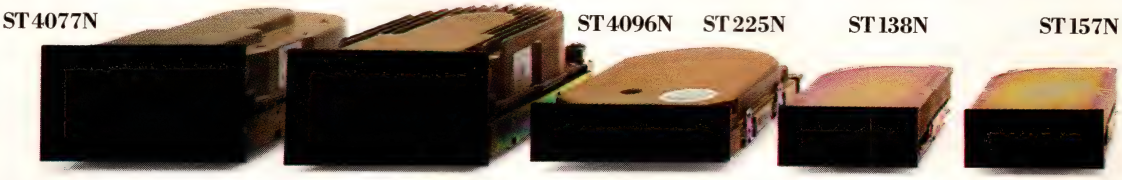

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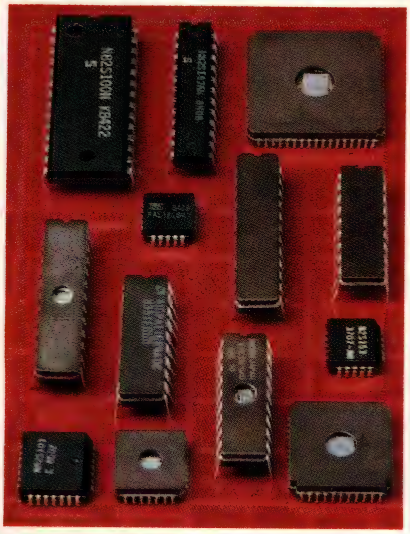

CIRCLE NO 200

NEWS BREAKS

EDITED BY JOAN MORROW

CHIP SETS BUILD 12-MHz IBM PC/AT CLONES

Add two more vendors to the growing list of companies offering multichip sets that allow you to drastically reduce the number of components on a high-speed, IBM PC/AT-compatible CPU board. Both companies package their CMOS IC sets in 84-lead PLCC packages, and both sets accommodate 80286 μPs with clock speeds to 12 MHz. The chip set from VLSI Technology Inc (Phoenix, AZ, (602) 893-8574) comprises five devices, including the VL82C100 peripheral controller, the VL82C101 system controller, the VL82C102 memory controller, the VL82C103 address buffer, and the VL82C104 data buffer. VLSI Technology claims that its ICs reduce the CPU board's component count from 110 to 16 ICs (excluding memory chips). The company offers a $225 sample kit of parts and projects volume pricing for the chip set at $68.85 (10,000).

Faraday's (Sunnyvale, CA, (408) 738-1671) 4-chip set includes the FE3000 CPU controller, the FE3010 peripheral-logic IC, the FE3020 address buffer, and the FE3030 data buffer. The company says its $80 (10,000) chip set reduces the number of ICs required to implement an IBM PC/AT-compatible CPU board from 95 to 19 and diminishes power consumption by more than 16W, a 50% reduction. You can experiment with these parts with a $995 starter kit that contains a CPU board incorporating the 4-chip set, a passive backplane, compatible ROM BIOS, schematics, and application notes.—Steven H Leibson

1G-SAMPLE/SEC DIGITIZER MIGRATES TO IEEE-488 BUS

The first version of the Sequence Inc (San Jose, CA) Series 3000 1G-sample/sec waveform digitizer required an IBM PC for operation; now the firm's $31,500 Model 3100 brings the same specs to IEEE-488 systems. The instrument has a 350-MHz analog bandwidth commensurate with its sampling rate. It features a 1024-sample memory and can dump the memory's contents over the bus in DMA mode. The digitizer sports 9.5 bits of effective resolution for 5-MHz waveforms and 8.0 effective bits at its maximum sampling rate.—Charles H Small

VME BUS BECOMES AN IEEE STANDARD—FINALLY

The IEEE (New York, NY, (212) 705-7960) standards board approved draft 2.0 of the standard developed over the past few years by the society's P1014 (VME Bus) working group. Working-group chairman Shlomo Pri-Tal of Motorola's Microcomputer Div (Phoenix, AZ, (602) 438-3000) and vice-chairman Thomas J Leonard of AT&T (Holmdel, NJ, (201) 949-1784) steered efforts on the proposed standard to a successful conclusion. The new standard, to be called IEEE 1014, should be available as a printed document sometime next month.—Steven H Leibson

G-64 BUS BOARDS SUIT PROCESS-CONTROL APPLICATIONS

Now available in the US are two G-64 Bus boards from MPL of Baden, Switzerland. The boards, marketed by Gespac Inc (Mesa, AZ), are aimed at industrial-control applications. The $425 MPL 4205 is a 16-relay interface card; each relay has two contacts that can drive 1A at 24V dc or 500 mA at 100V ac. LEDs indicate the status of each relay.

The MPL 4210 serial-interface board handles 4-channel asynchronous data communications at rates to 19,200 baud. One version supports RS-232C only, one supports RS-232C and -422, and one supports RS-232C and -422 and provides a 20-mA current loop. (The RS-422 and current-loop modes allow 9600-baud communications over a 3000-ft link.) Price ranges from $395 to $875.—Rick Nelson

244M-BYTE WORM DRIVE AND SOFTWARE ENHANCE IBM PC, PC/AT

Devices in the APX-3000 Series combine a WORM (write-once, read-many) optical disk drive, a controller card with connecting cable, and an appropriate software device driver for MS-DOS versions 2.0 through 3.2. From Maximum Storage Inc (Colorado Springs, CO, (303) 531-6888), the series allows application programs running on IBM PC, PC/AT, or compatible computers to access 122M bytes of information. The manufacturer offers 1- and 2-sided cartridges for a maximum storage capacity of 244M bytes/cartridge.

A $2695 internally mounted version (APX-3100) incorporates a split front bezel on the drive, which allows you to mount the product in either a full-height slot or the lower slot of a PC/AT. The external version (APX-3200) costs $2895, and the media for both drives costs $75 for single- and $95 for double-sided cartridges. Both versions of the product transfer information at 2.5M bps and feature a 135-msec average access time and 1-msec track-to-track seek time.—Steven H Leibson

ROUTER, WORKSTATIONS HANDLE VARIETY OF PC-BOARD LAYOUT TASKS

A variable-grid routing package from Calay Systems (Irvine, CA, (714) 863-1700) for the company's line of pc-board CAD workstations allows you to select grid sizes of any resolution. This feature, in turn, lets you lay out your boards on nonstandard grids, a feature necessitated by the advent of SMDs and other new technology components that have odd, or nonstandard, lead spacings. The package is standard on the Calay's new DA5000 PCB-CAD workstation or comes as a $5000 option for the DA3000 workstation.

Also new from Calay Systems is a family of pc-board design workstations that can handle entry-level to high-performance pc-board layout applications. The entry-level DA1000 system features 100% hardware autorouting, interactive graphics, and post-processing software. The DA3000 improves upon the DA1000's graphics performance, offers more autorouting options, and provides a twofold improvement in overall performance. The high end of the family is represented by the DA5000 workstation which, in addition to the features found on the previously mentioned workstations, brings the services of a RISC-based autorouting accelerator to bear on the task of pc-board layout. The DA1000 costs $65,000, the DA3000 is $90,000, and the DA5000 is $120,000.—Jim Wiegand

HARD-DISK DRIVE PARKS HEADS WHEN NOT IN USE

The Model 3650 half-height, 5¼-in. hard-disk drive from Miniscribe (Longmont, CO, (303) 651-6000) parks its heads over a vendor-defined, nondata landing zone after 30 seconds of drive inactivity to protect against data loss. A 3-color LED on the drive's front panel glows green during normal operation, blinks error codes in red, and shows amber when the heads are parked. The drive incorporates a standard ST-412/506 interface, stores 50.5M bytes (unformatted) on six surfaces, features a 61-msec average access time, and consumes 18.6W. The Model 3650 costs $350 (500).—Steven H Leibson

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NEWS BREAKS: INTERNATIONAL

SMT AND HYBRID TECHNIQUES COMBINE TO INCREASE CIRCUIT DENSITY

By using naked-die ICs and ASICs with a combination of direct chip bonding, thick-film-circuit, and surface-mount techniques, the Megablock integration system from Newmarket Microsystems Ltd (Newmarket, UK, TLX 81358) allows you to increase circuit density by utilizing three-dimensional-circuit construction. The system employs SIP hybrid modules connected to surface-mount daughter boards, which plug into a conventional pc board. As an example, the company proposes a single-Eurocard, 120M-byte memory board with a height of around 50 mm, which integrates over 900 cm of silicon onto the 160×100-mm pc-board area.—Peter Harold

COMPLEX ACCUMULATOR HAS 20-MHz THROUGHPUT IN FFT APPLICATIONS

Capable of continuous 20-MHz throughput, the PDSP16316A complex accumulator from Plessey Semiconductors Ltd (Swindon, UK, TLX 449637; in the US, (714) 472-0303) incorporates two 20-bit adder/subtracters or accumulators, which you can use to simultaneously process the real and imaginary parts of complex numbers. Alternatively, you can allocate the entire device to real or imaginary data to create, for example, radix-2 butterflies.

The device has two 16-bit input ports and two 16-bit 3-state output ports. A shifter on the output of each adder/subtracter allows you to select eight different 16-bit segments of the 20-bit result. The PDSP16316A is compatible with other devices in the company's PDSP Series and includes a 7-cycle de-skew register to resynchronize data that has not passed through a PDSP16112 complex multiplier. The PDSP16316A costs $132 (1000). A 10-MHz version is available for $82.50 (1000).—Peter Harold

VENTURE ESTABLISHED TO DEVELOP SUPERCONDUCTIVE MATERIAL

Japan's Science and Technology Agency plans to organize a research and development program that will produce commercially viable superconductive materials. Part of the program calls for the New Superconductive Material Research Committee to become a corporation and to establish a separate research organization that will allow scientists from government, universities, and industry to conduct joint research. As much as ¥10 billion ($66.7 million) from the national budget might be allocated to this program. The Science and Technology Agency has expressed an interest to expand this project to an international level.—Joan Morrow

NAKAMICHI MAKES JAPAN'S FIRST STREAMING TAPE DRIVES

Nakamichi, best known for its high-end stereo components, is the first Japanese company to manufacture ½- and ¼-in. magnetic tape streaming tape drives to back up hard-disk data. The first 15,000 will be delivered to American OEM Scientific Micro Systems (Mountain View, CA). The CP240 ½-in. drive is a 24-track unit featuring a 240M-byte capacity, a 90k-bps data-transfer speed, and a 79.8-in./minute tape speed. It costs approximately ¥120,000 ($800). The ¼-in. device comes in two versions: the 60M-byte, 9-track CP-60 and the 125M-byte, 15-track CP-125. Prices are $200 and $233, respectively.—Joan Morrow

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3	●	●■	●	●
4	●	●	●	●
5	●	●	●	●
6	●	●■	●	●
7	●	●	●	●
8	●	●	●	●
9	●	●	●	●
10	●	●■	●	●
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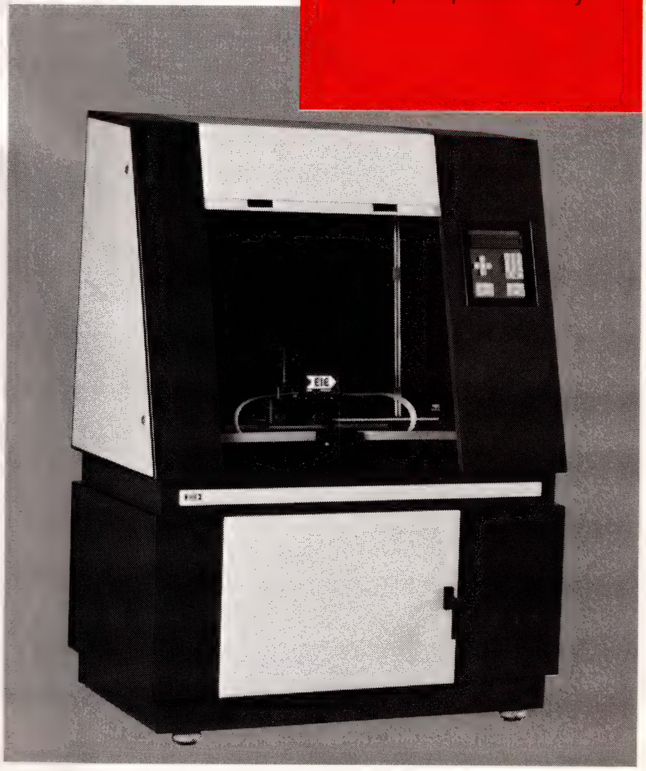

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HC/HCT7046

- Operating frequency range up to 17 MHz (fc) at Vcc=4.5V.
- Built-in op amps for excellent linearity.
- Op-amp buffered demodulated output.
- A pin which indicates lock detect.
- 2 phase comparators to choose from.
- Applications: FM Modulation/Demodulation, Frequency Synthesis, Frequency Multiplexing, Voltage to Frequency/Frequency to Voltage Conversion, Servo Control Systems, Data Synchronization, Manchester Coding/Decoding.

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SIGNALS & NOISE

The engineer's lot is not so bad

I am sick and tired of hearing all these engineers complain about what a rotten deal they keep getting. Yes, I agree with Mr Feerst [his letter appeared in EDN, March 18, on pg 30] that engineering as a *profession* leaves something to be desired. We do not get the prestige (or the money!) that doctors and lawyers do. However, as a career compared to the average job, engineering ranks pretty well, wouldn't you say?

My husband, for example, has a bachelor's degree from a 4-year institution. At the moment, his career is in social work; he works for a private foundation. He makes *less than half* what I do. He performs a vitally needed function in our society, helping people to recover from mental illness. I'm sure that what I do is not as necessary to the functioning of society as a whole, yet I am paid much more.

Every year, the IRS comes out with its average statistics. Last year, it said the average family of four earned $25,000. A college grad with an EE degree can get that right out of school. I know I couldn't survive on $25,000 a year, and I don't know how a family with two kids does it, either.

Engineers don't have a monopoly on layoffs, either. There are plenty of auto workers, steel workers, and others who would let you know, I'm sure.

As a final point, let me just say that a technically literate society is necessary in this day and age, and will be even more necessary as time goes by. If more students are not encouraged to become engineers or at least to be technically knowledgeable, we will have a badly stratified society, with an ignorant, superstitious rabble ruled by a technocracy (but I suppose *then* the engineer will have more prestige). The technocrats will be the first against the wall when the revolution comes.

Wendy Alexandar
Concurrent Computer Corp
Tinton Falls, NJ

Give youths a realistic picture of engineering

Jon Titus's editorial "Youngsters deserve a look at engineering" (EDN, December 11, 1986) really grabbed my attention, and, having been an engineer for 20 years, I feel urged to share an important perspective.

The editorial leaves no doubt where Mr Titus stands. At the beginning he states "It's time to tell more young people, particularly those in high school, about engi-

Text continued on pg 36

Cherokee has the switchers to handle your disk drive power requirements. All of them.

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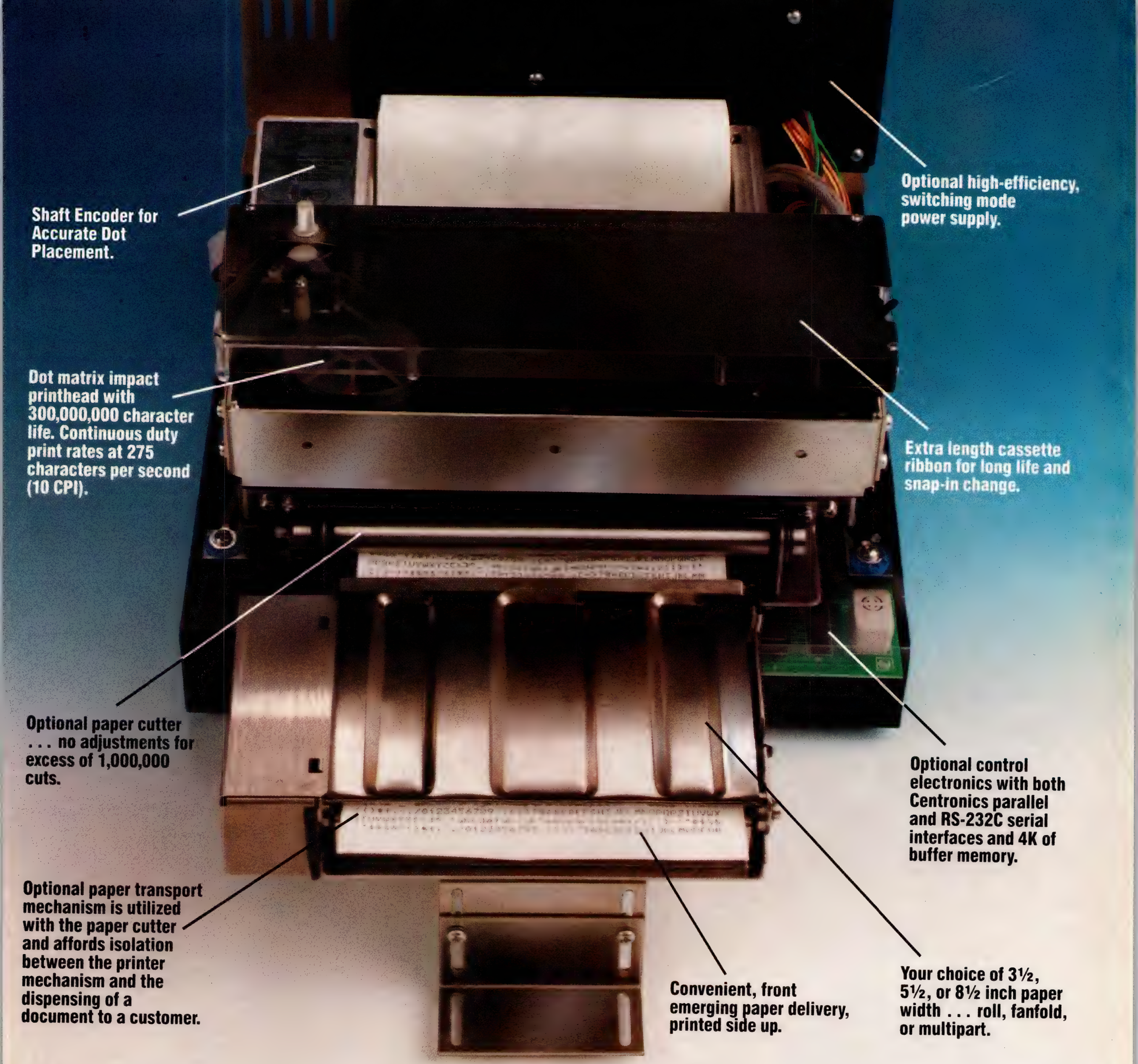

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CIRCLE NO 204

TEK'S NEW EASY-TO-EXPERT LOGIC ANALYZER $3995.*

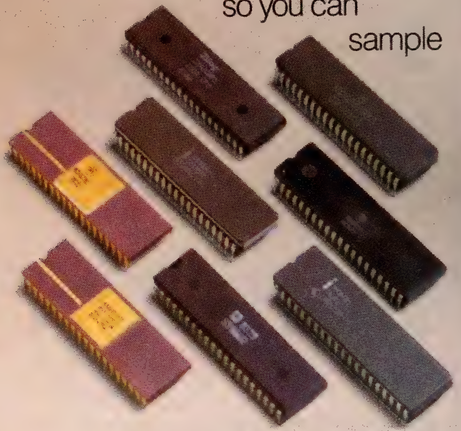
Introducing the Tek 1220 and 1225: the two newest members of the Tek 1200 Series of logic analyzers. Nothing else in their price range delivers so much and makes it all so easy to use. Consider:

1 Powerful state, timing and disassembly analysis. The 1220 and 1225 provide 32 or 48 data channels, respectively, in groups of 16-channels, with channel groups clocked independently or linked together — so you can sample data from as many as three circuit sections at once.

Tek currently provides support for the most popular microprocessors, with additional 8- and 16-bit personality modules to be introduced continually.

2 A total of four 2K nonvolatile memories support each channel. Acquire data in one memory and compare it to data in any of the three other memories.

Clock/calendar plus storage for up to eight test setups are also in battery-backed memory. Date and time of storage are included with each data memory, so it's easy to find and interpret results.



```
THU, DEC 18, 1986  Disasm: Sample 2    14:58   CONTROL1
Loc   Addr Data          Z80 Disassembly       Operation
0504  0503 3A0444     LD      A,(4404)         4404=00
0508  0506 FE01       CP      01
0510  0508 20FF       JR      NZ,040B
TRIG  0000 C30001     JP      0100
0515  0100 31FF7F     LD      SP,7FFF
0518  0103 CDCB04     CALL    04CB             7FFD=0106
0523  04CB ED4D       RETI                     7FFD=0106
0527  0106 CDC802     CALL    02C8             7FFD=0109
0532  02C8 3E4F       LD      A,4F
0534  02CA D392       OUT     (92),A            92=4F
0537  02CC 3E0A       LD      A,0A
0539  02CE D392       OUT     (92),A            92=0A
0542  02D0 3E03       LD      A,03
0544  02D2 D392       OUT     (92),A            92=03
0547  02D4 DB90       IN      A,(90)            90=01
0550  02D6 3E0F       LD      A,0F
0552  02D8 D393       OUT     (93),A            93=0F
0555  02DA 3E0C       LD      A,0C
0557  02DC D393       OUT     (93),A            93=0C
0560  02DE 3E03       LD      A,03
Fmt:F  Scroll: ▲ ▼  Curs 0,1   Loc TRIG:2   Loc Spec:J
```

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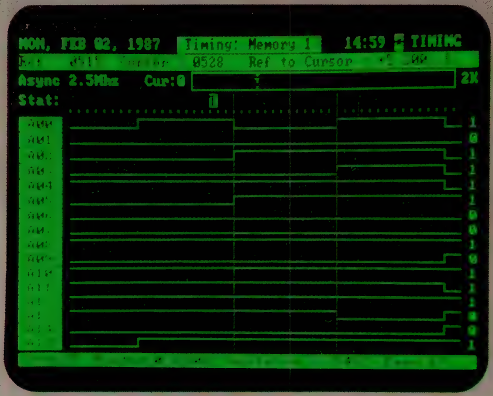
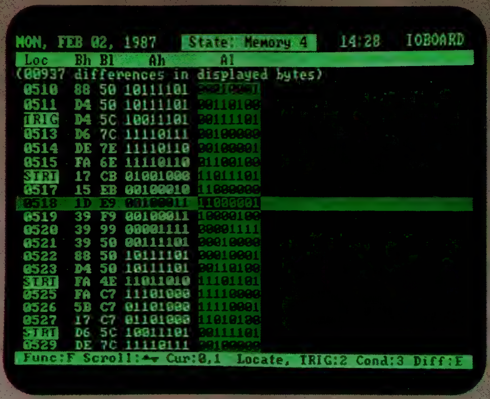


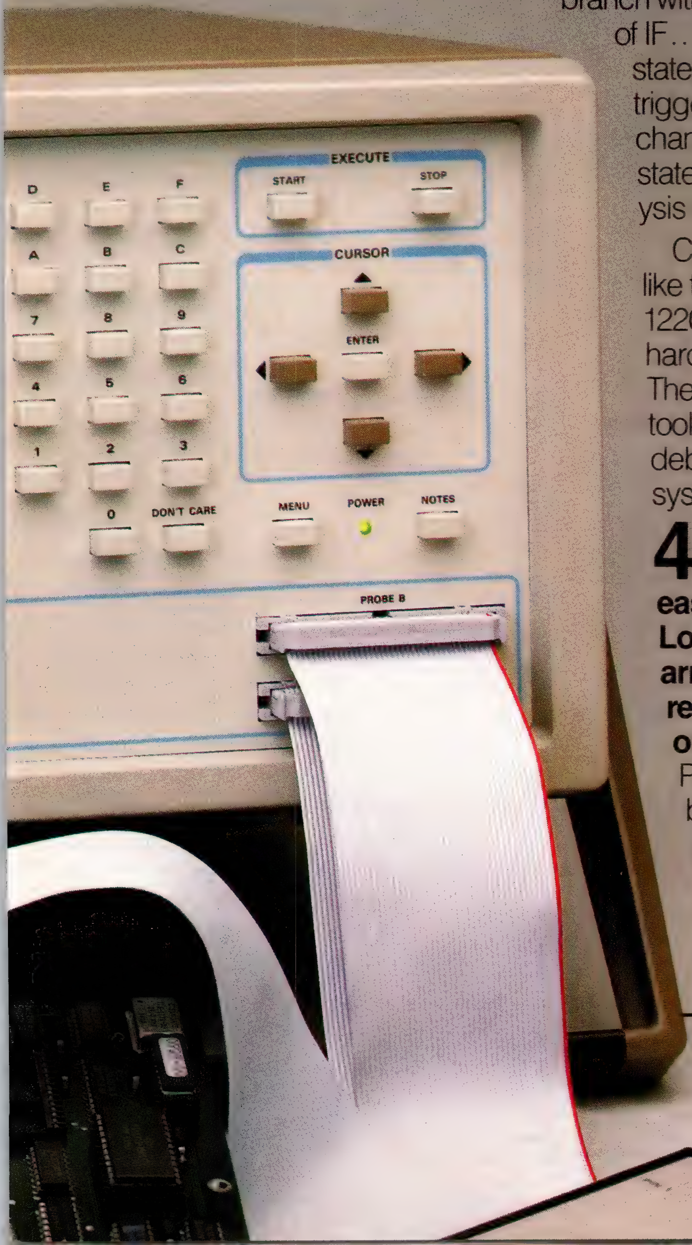
```
MON, FEB 02, 1987  Timing: Memory 1   14:59   TIMING
                   0528  Ref to Cursor
Async 2.5Mhz   Cur:0                                2K
Stat:
```



```
MON, FEB 02, 1987  State: Memory 4  14:28  IOBOARD
 Loc   Bh Bl   Ah       Al
(00937 differences in displayed bytes)
 0510  88 50 10111101 [illegible]
 0511  D4 50 10111101 00110100
 TRIG  D4 5C 10011101 00111101
 0513  D6 7C 11110111 00100000
 0514  DE 7E 11110110 00100001
 0515  FA 6E 11110110 01100100
 STRT  17 CB 01001000 11011101
 0517  15 EB 00100010 11000000
 0518  1D E9 00100011 11000001
 0519  39 F9 00100011 10000100
 0520  39 99 00001111 00001111
 0521  39 50 00111101 00010000
 0522  88 50 10111101 00010001
 0523  D4 50 10111101 00110100
 STRT  FA 4E 11011010 11101101
 0525  FA C7 11101000 11110000
 0526  5B C7 01101000 11110001
 0527  17 C7 01101000 11010100
 STRT  D6 5C 10011101 00111101
 0529  DE 7C 11110111 00100000
Func:F Scroll:▲▼ Cur:0,1  Locate, TRIG:2 Cond:3 Diff:E
```

Left Set reference cursors on the timing diagram to measure pulse width or the time between pulse edges. **Above** State tables are displayable in binary or hex formats.

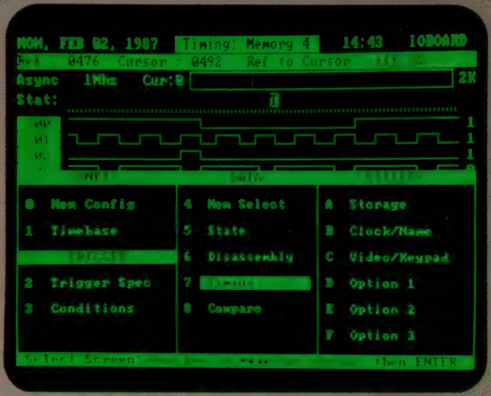
Use the optional interfaces to control the instruments via computer and attach inexpensive dot matrix printers for immediate documentation.



3 Triggering can be as simple or sophisticated as you choose. Specify up to 24 trigger conditions. Conditionally branch with up to 12 levels of IF . . . THEN . . . ELSE statements. Cross-trigger between channel groups. Do state and timing analysis simultaneously.

Capabilities like these make the 1220/1225 more than hardware analyzers. They are capable tools for both software debugging and system integration.

4 Pop-up menus are easy to use. Logically arranged. And respond instantly on command. Push one button for on-screen notes appropriate to the current display.



```
MON, FEB 02, 1987  Timing: Memory 4   14:43   IOBOARD
     0476  Cursor = 0492  Ref to Cursor
Async   1Mhz   Cur:0                               2K
Stat:
 0  Mem Config       4  Mem Select       A  Storage
 1  Timebase         5  State            B  Clock/Name
                     6  Disassembly      C  Video/Keypad
 2  Trigger Spec     7                   D  Option 1
 3  Conditions       8  Compare          E  Option 2
                                         F  Option 3
 Select Screen:                              then ENTER
```

Above Pop-up menus, such as this main menu, are easy to understand and logically arranged.

5 This is affordable logic analysis in a league by itself. Users can evolve from one unit to another, through the entire 1200 Series, with a minimum of readjustment. You can be confident that Tek quality is built in, and that documentation and service will be there when required.

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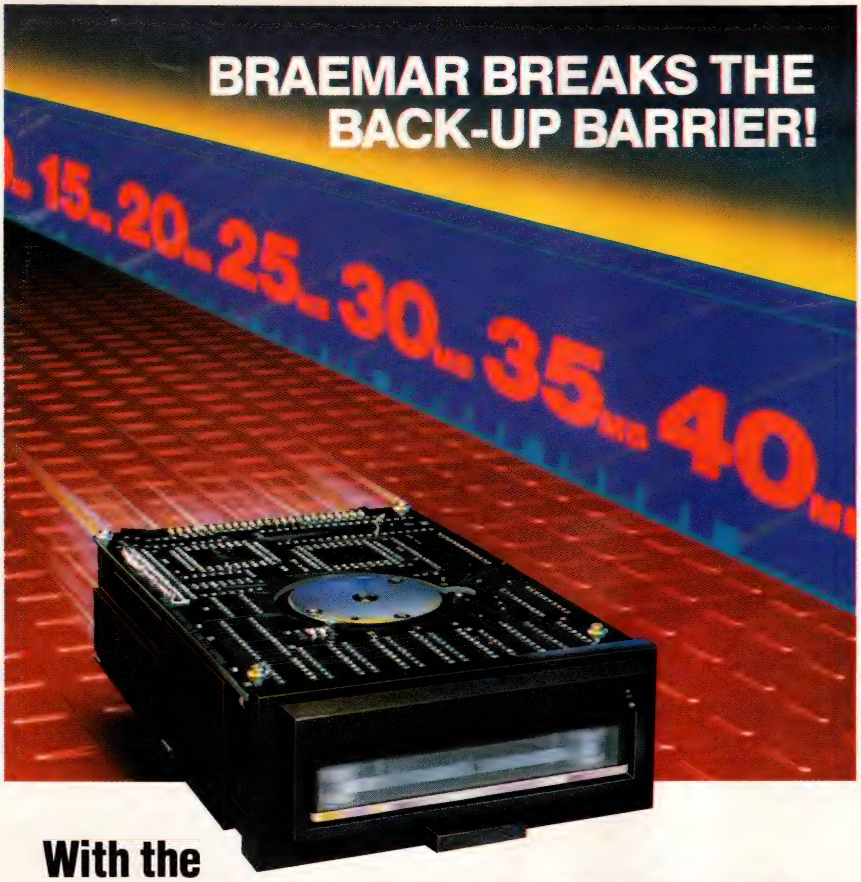

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CIRCLE NO 15

DID YOU KNOW?

Half of all EDN's articles are staff-written.

EDN

neering careers." The conclusion stated: "To keep our profession active, we need a steady supply of vital, eager newcomers."

Why do we need a steady supply of newcomers to keep our profession active? Because the engineers already in the profession five, 10, or even more years are no longer vital and eager, but are stagnating and depressing the vigor of the profession? Or do we need a steady flow of newcomers for some companies that regularly lay off their experienced people and hire June grads to replace the older men—at lower salaries, of course?

The editorial did make a sound statement: "A realistic exposure to engineering and its rewards might strengthen a high-school student's resolve to spend four years in a tough academic program. Such an exposure also risks turning away some youngsters who might otherwise study engineering." I could not agree more. And a "realistic exposure" must include the following:

- An honest statement about the extent and nature of the chronic layoffs of engineers. To gloss over the chaotic "career adjustments" that many engineers experience is to unconscionably deceive would-be engineers.
- A realistic statement about advancement in the engineering field. The statement must address the question of why many engineers believe that they must move to another company in order to advance.
- A frank addressing of the issue of why so many engineers spend a disproportionately large time doing subengineering tasks, and why many others do work that they had no intention of doing when they were hired.

I'm not saying, "Let's discourage all high-school students from looking into engineering careers." I do say that we engineers must emphasize realistic and honest exposure to

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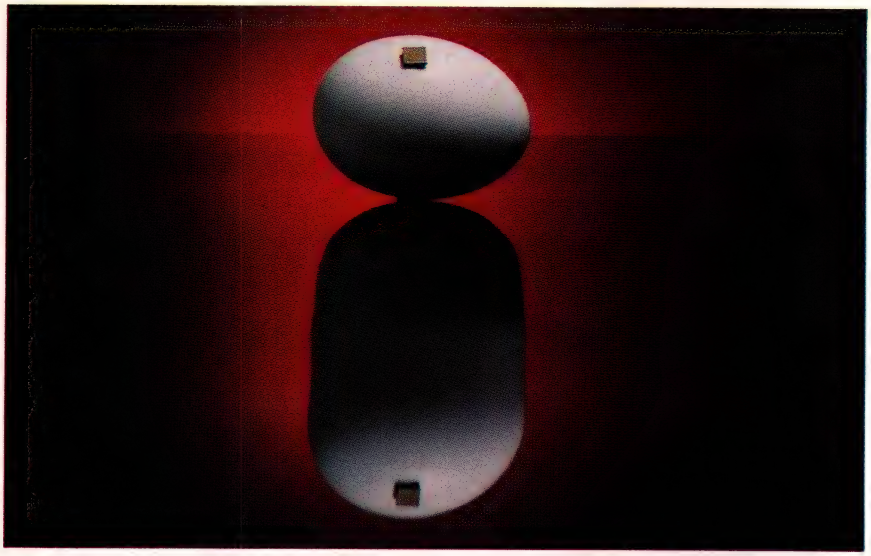

Reducing Thermal Stress in MLC Chips

Surface mount manufacturing processes directly expose components to soldering temperatures which can cause reliability problems when the rate of rise in temperature is too rapid. Multilayer ceramic capacitors (MLCs) like many components are sensitive to this thermal shock. This sensitivity is not only due to their material properties but also their construction, design, manufacturing and assembly techniques. Toward decreasing this thermal stress, AVX has been studying the effects of ceramic formulations, electrode configurations, chip dimensions, end terminations, mechanical flaws, and soldering parameters.

Thermal Stress

When ceramics are subjected to a rapid change in temperature (such as plunging MLCs into a solder bath) stresses result because the surface reaches the new temperature almost instantly while the interior remains at some lower temperature causing a temperature gradient, $\triangle T$.

As shown in Equation 1, thermal stress is the function of the square of the chip thickness. Therefore, this parameter is very important in chip design and subsequent thermal shock behavior.

Equation 1
THERMAL STRESS

$$\sigma = \frac{E\,\alpha}{(1-\mu)} \; \frac{s\,\phi\,t^2}{(k/\varrho\,C_p)}$$

E : ELASTIC MODULUS (DIFFICULT TO CHANGE)

α : COEFFICIENT OF THERMAL EXPANSION

ϕ : RATE OF CHANGE OF TEMPERATURE (CAN BE CONTROLLED)

t : HALF THICKNESS FOR A PLATE (CAN BE EASILY CHANGED)

μ : POISSON'S RATIO (CHARACTERISTIC OF THE SYSTEM)

s : SHAPE FACTOR (CHARACTERISTIC OF THE SYSTEM)

$k/\varrho\,C_p$: THERMAL DIFFUSIVITY (CAN BE CHANGED BY ADJUSTING METAL TO CERAMIC RATIO)

EFFECT OF THICKNESS ON THERMAL SHOCK OF MLC CHIPS

SOLDER DIP TEST RESULTS AT 260°C, NO PREHEAT

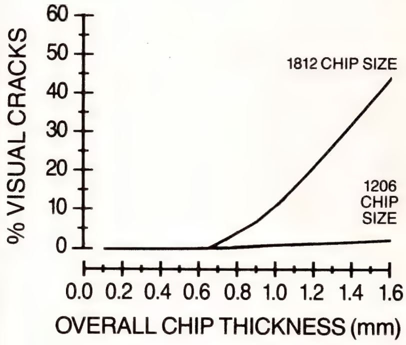

Figure 1

Test Results

Solder tests were run by directly dipping various chip thicknesses into molten solder at 260°C with no preheat. Chip formulation and termination known to have cracking problems under these conditions were chosen for the test. The chips were then visually inspected for any cracking. The results are plotted in Figure 1. They confirm that as the thickness increased the number of visual cracks increased. It should also be noted that as the part size increased for a constant chip thickness the visual cracks increased. This would be expected since the larger the geometries the greater the internal thermal mismatch.

Discussion

This information along with data on other parameters is being utilized by AVX to design MLC chips for minimum thermal stress in soldering operations. For a technical paper discussing these parameters, complete and return the coupon below.

☐ Please send me the AVX Technical Paper "Factors Responsible for Thermal Shock Behavior of Chip Capacitors."
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AVX Technology For The Times

the profession, and that we cannot unrestrainedly urge youngsters to enter. To do otherwise is to risk in the long run a mass exodus from the profession, such as those we have been seeing in teaching, and even in medicine. And he who would indiscriminately sell the public on engineering careers risks losing his credibility—if not with the public, then certainly with the engineering profession.

The best statement in the editorial was this: "We all benefit by putting students on paths to careers they'll enjoy, whether or not the careers are in engineering."

Name withheld upon request

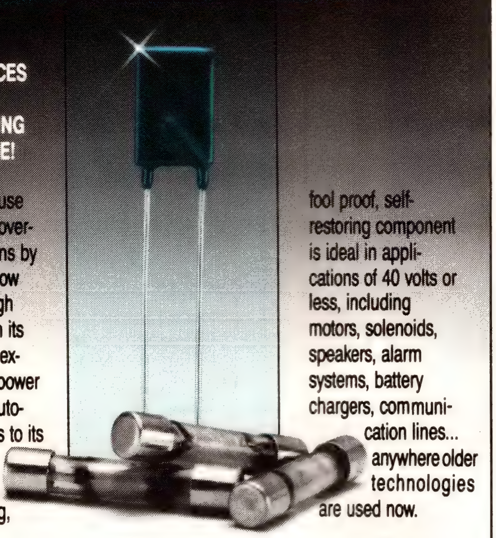
Thermal-data update

Since the publication of the technology update "Cost, device speed, size, and reliability determine the best package for an ASIC" (EDN, April 30, pg 77), LSI Logic has updated the table of typical thermal data that accompanies the article. The updated table appears here.

TYPICAL THERMAL DATA

PACKAGE TYPE	θ_{JC} (°C/W)	θ_{JA}(STILL AIR) (°C/W)	θ_{JA}(300 FT/MIN AIR) (°C/W)
24-LEAD DIP—CERAMIC	15 TO 20	45 TO 55[1]	30 TO 40
—PLASTIC		80 TO 100	60 TO 70
40-LEAD DIP—CERAMIC	12 TO 17	40 TO 50[1]	25 TO 35
—PLASTIC		40 TO 60	30 TO 40
68-LEAD PLASTIC CHIP CARRIER (J-BEND)		35 TO 40[1]	25 TO 30
CERAMIC PIN-GRID ARRAY (CAVITY UP) 100 TO 144 LEADS	6 TO 10	20 TO 25[2]	15 TO 20
CERAMIC PIN-GRID ARRAY (CAVITY DOWN) 155 LEADS	3 TO 6	15 TO 20[3]	10 TO 15
299 LEADS	3 TO 6	10 TO 15[3]	6 TO 10
PLASTIC PIN-GRID ARRAY (CAVITY UP) 100 TO 144 LEADS	8 TO 12	25 TO 30[3]	20 TO 25

NOTES:
1. DIE SIZE IS 200 MIL²
2. DIE SIZE IS 380 MIL²
3. DIE SIZE IS 573 MIL²



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DT2803 Frame Grabber	256x256x6	✓		✓	$1495.

Array Processing

Model	FFT* 1024 Point Real	FFT* 1024 Point Complex	FFT* 256x256 Image	Software	Price
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*All execution speeds are real-world, not theoretical, and include overhead times.

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DT2811	✓	✓	12-bit	20kHz	✓	$199-$745

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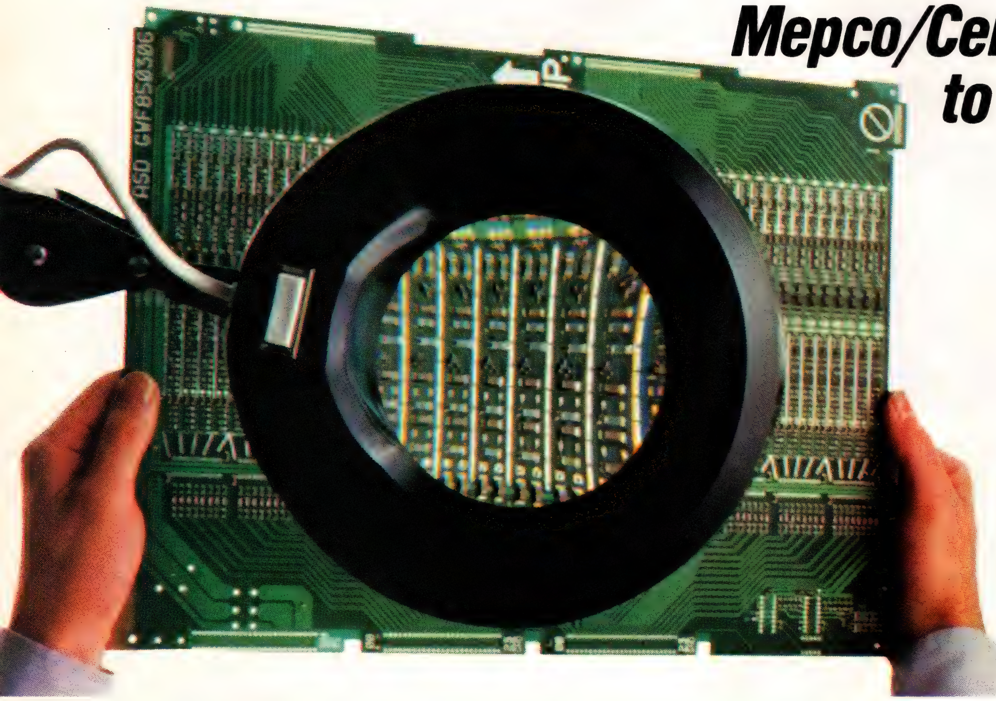


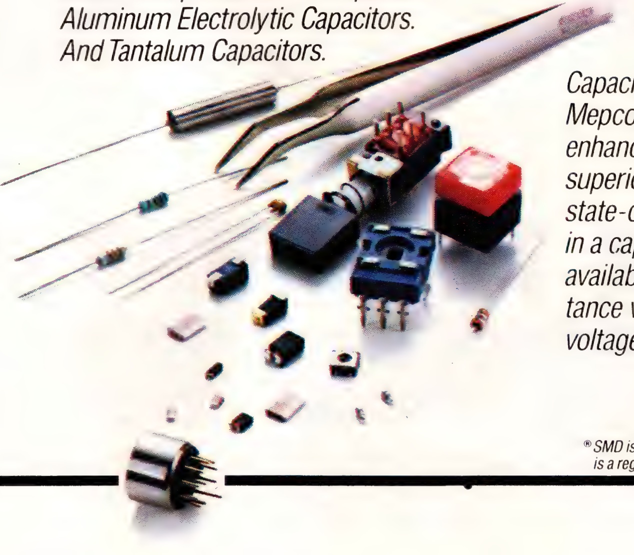
We know you face stiff competition with your next generation of products. We're actively working to help you stay in front.

Starting with substantial investments in research and development and in product, process and mechanization engineering, we have committed all of our resources to a single goal: to be the leading source for the advanced, reliable passive components you'll need in the months and years ahead.

Broadest line of passive components in the U.S.

Since we've combined the resources of Mepco//Electra and Centralab, we can meet your needs better than ever. We offer the broadest line of passives in the industry. Both leaded and surface mount. And we're adding new components, new configurations and new packaging alternatives all the time.

For example, we challenge you to find a supplier that can match Mepco/Centralab's wide selection of capacitors. Ceramic Capacitors. Film Capacitors. Aluminum Electrolytic Capacitors. And Tantalum Capacitors.



We also have a broad selection of resistors, including Thick Film Chip Resistors. Metal Film Resistors. Precision MELF Resistors. Nonlinear Resistors. And Trimming Potentiometers.

Our electromechanical line includes Rotary and Pushbutton Switches. Keyswitches. Membrane Switches made to your precise specifications. And custom or standard Potentiometers.

Leading in SMDs®: selection, performance and reliability.

We can meet your growing needs for superior component performance in small sizes. We offer the largest selection of passive Surface Mount Devices (SMDs) in the industry, many with unique performance advantages. For example, our BLUE CHIP® Tantalum Capacitor has achieved worldwide recognition for reliability in many applications that demand outstanding electrical characteristics in a very small size.

Our SMD Ceramic Chip Capacitors are another example of how Mepco/Centralab can help you greatly enhance circuit board density with superior SMD components. They offer state-of-the-art volumetric efficiency in a capacitance device. And they're available in a wide selection of capacitance values, dielectric materials and voltage ratings.

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Japan Electronics:
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The Japan Electronics seminar on October 7 in Osaka is designed to help European and U.S. executives seek out new business opportunities in Japan. The day-long seminar, which will coincide with the Japan Electronics Show, has been structured to provide attendees with a statistical overview of the Japanese electronics industry, as well as a preview of upcoming technological trends.

The seminar is intended both as an introduction to Japan for first-time visitors as well as an update of Japanese business and technology for seasoned travelers in the Far East. If you buy from, compete with, or sell to Japanese electronics companies, this seminar is for you.

DATE:
October 7, 1987
In conjunction with the Japan Electronics Show

LOCATION:
Royal Hotel,
Osaka, Japan

SEMINAR FEE:
$350

OFFICIAL LANGUAGE:
English

CO-SPONSORS:
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U.S. Electronics Industry Japan Office
Japan Electronics Show Association
Osaka Chamber of Commerce and Industry
EDN magazine
Elektronica of Holland
Plesman Publications of Canada

CONFIRMED SPEAKERS:

Kaoro Kubo, vice president and general manager of NTT International. "The Japanese telecommunications industry: Opportunities for foreign suppliers"

Kazuhiko Kobayashi, manager of the Systems Engineering Division of Hitachi Ltd. "Factory automation in the Japanese computer industry"

Hiroshi Komiya, head of the Saijou Works, Mitsubishi Electric Corp. "Manufacturing technology in the semiconductor industry"

Bill Totten, president of Ashisuto K.K. "The Japanese market for U.S. and European software"

David H. Johnson, senior manager for Network Systems Sales, AT&T International. "Opportunities for U.S. communications manufacturers in Japan"

Dinker Bir, vice president of technology at Northern Telecom Japan Inc. "Trends in telecommunications"

Pat O'Malley, strategic marketing director for the Semiconductor Sector at Nippon Motorola Ltd. "The Japanese semiconductor market"

Gen Narui, regional manager for Educational Services at Nihon Digital Equipment Corp. "Recent developments in artificial intelligence at DEC"

Stephen Donovan, representative director of Monolithic Memories K.K. "Selling niche products in Japan"

Shohei Kurita, Tokyo editor for Electronic Business, author. "The Fifth Generation Computer Project"

Gene Norrett, vice president and director of the Semiconductor Industry Group, Dataquest Inc. "Electronics trends among countries on the Pacific Rim"

Alberto Socolovsky, associate publisher and editorial director of Electronic Business. "Structural differences between the U.S. and Japanese electronics industries"

Speaking on "Trends in consumer electronics":

Nobuyoshi Yokobori, manager of the R&D Planning Office, Corporate Engineering Division, Matsushita Electric Industrial Co. Ltd.

Masaru Yamano, executive vice president, Sanyo Electric Co. Ltd.

Tadashi Sasaki, corporate management advisor, Sharp Corp.

Nobuo Tateishi, executive vice president, Omron Tateishi Electronics Corp.

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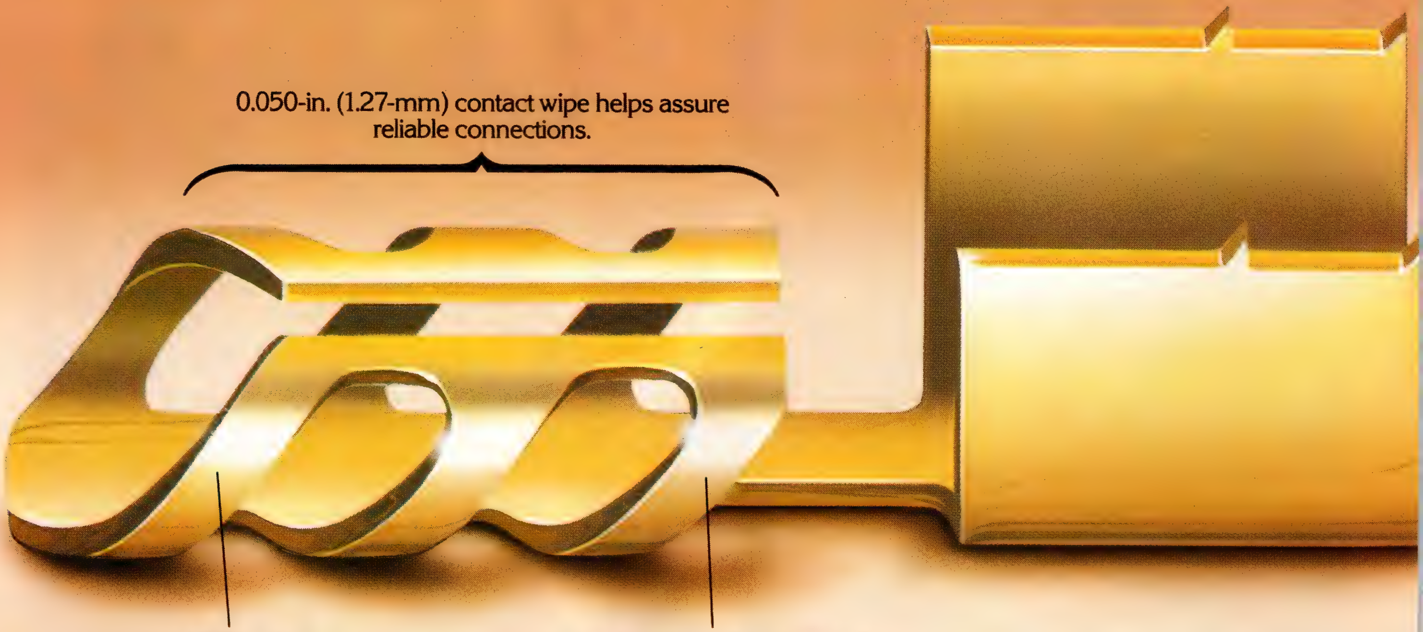
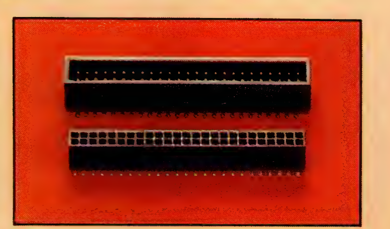

0.050-in. (1.27-mm) contact wipe helps assure reliable connections.
Du Pont RIB-CAGE™ connectors feature a three-rib contact that delivers 100 grams of normal force.
Patented RIB-CAGE design is highly resistant to shock and vibration.

Big performance. Little package.


Actual size of 50-position 0.050-in. (1.27-mm) vertical surface-mount RIB-CAGE card connector and mating male header.

Du Pont RIB-CAGE™ connectors deliver 100-gram normal force in miniature/microminiature interconnects.

The patented RIB-CAGE connector terminal design, magnified above, is how Du Pont packs 0.100-in. centerline connector performance into miniature packages like the 50-position vertical card connector shown in inset photo.

The exclusive angled rib design creates a contact area large enough to produce a normal force of 100 grams, with remarkably high shock and vibration resistance. The 0.050-in. (1.27- mm) contact wipe helps assure reliable contacts even through repeated cycles.

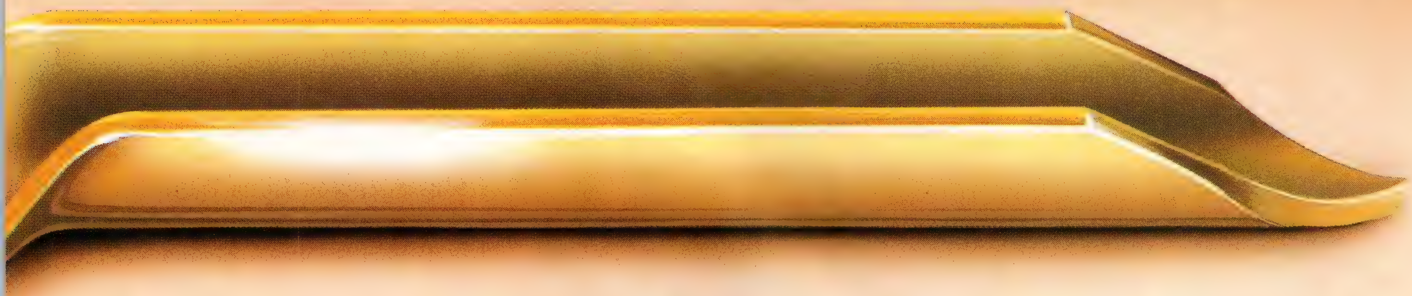
You also get inductance, capacitance, and impedance values that deliver signal speeds faster than 0.100-in. centerline designs plus high current capacity (see chart) and low circuit resistance.

That's what we mean by big performance.

Little package, high density.

Your designs benefit from a significant increase in surface density. RIB-CAGE connectors on 0.050-in. centers take up *one-eighth* the volume of 0.100-in. centerline connectors. And the

Berg Electronics is now



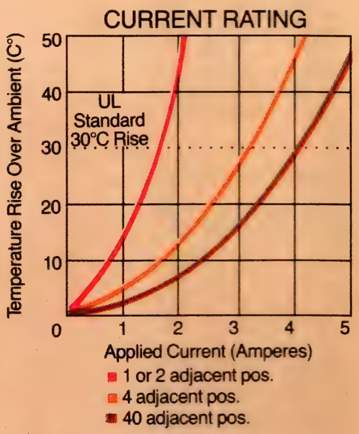
Shown above: 60X illustration of terminal used in RIB-CAGE connectors. Actual length is 0.250 in.

low profiles delivered by RIB-CAGE connectors mean tight stacking: 0.225 in. (5.72 mm) between substrates for through-mounts, 0.252 in. (6.40 mm) for surface-mounts. Profiles as low as 0.18 in. have been achieved for special applications.

Plenty of design flexibility.

The RIB-CAGE product family, currently tooled on 0.050-in. centers, offers the choice of vertical card connectors, interboard connectors, and pin grid array sockets. Through- and surface-mount configurations are available as well as single- and dual-entry designs.

The versatile RIB-CAGE design can accommodate a variety of applications including wire products both discrete and cable and right-angle horizontal card connectors.



Each RIB-CAGE connector is made with a plastic lead-in to protect the contact during mating. Polarized housings assure proper mating. And housings of Du Pont RYNITE® polyester resins resist vapor phase soldering temperatures.

Contact Du Pont for RIB-CAGE specifics.

Fill out the reader service card for complete information on RIB-CAGE connectors. For a sample kit of current RIB-CAGE connectors, call us toll-free, or write on your letterhead. Write to Rib-Cage Product Manager, Du Pont Connector Systems, 515 Fishing Creek Road, New Cumberland, PA 17070. Or make the Du Pont Connection: 800 932-7979. In Penna., call 800 222-2194.

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CIRCLE NO 19

CALENDAR

Single-Chip DSP Processors and VLSI Semicustom Architectures, Boston, MA. DSP Associates, 18 Peregrine Rd, Newton, MA 02159. (617) 964-3817. June 8 to 9.

IEEE MTT-S International Microwave Symposium, Las Vegas, NV. Steven March, Symposium Steering Committee Chairman, Maury Microwave Corp, 8610 Helms Ave, Cucamonga, CA 91730. (714) 987-4715. June 9 to 11.

University / Government / Industry Microelectronics Symposium, Rochester, NY. Lynn Fuller, Rochester Institute of Technology, 1 Lomb Memorial Dr, Rochester, NY 14623. (716) 475-2035. June 9 to 11.

Troubleshooting Microprocessor-Based Equipment and Digital Devices, Atlanta, GA. Micro Systems Institute, 73 Institute Rd, Garnett, KS 66032. (800) 247-5239. June 9 to 12.

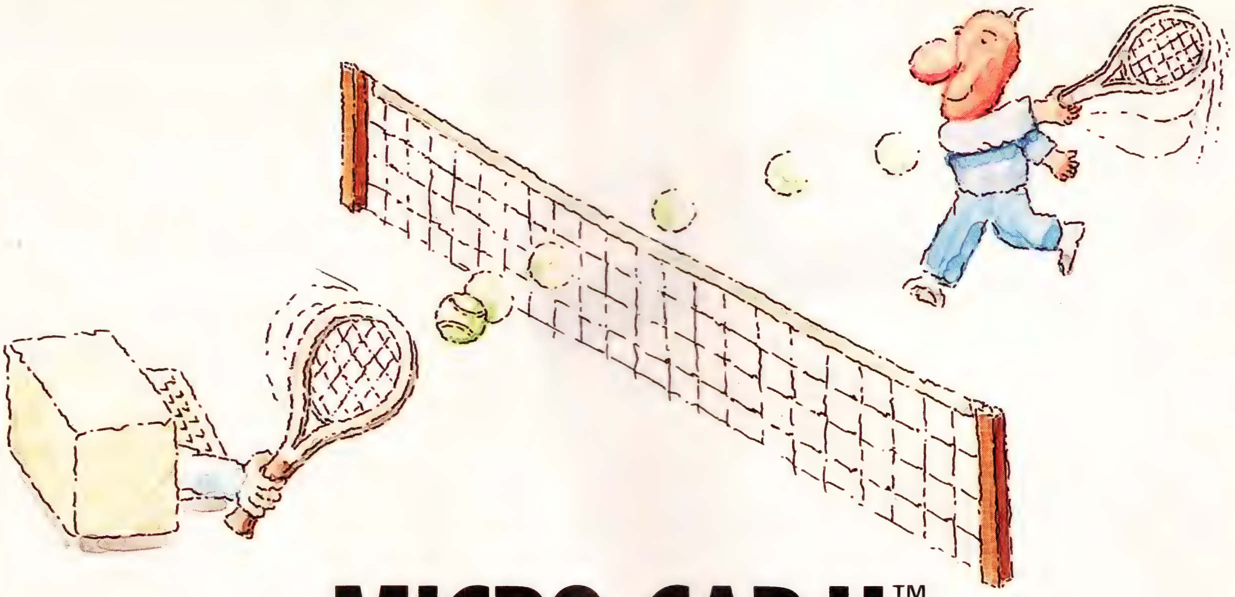
Advanced Printed Circuit Board Design Techniques, Milwaukee, WI. Center for Continuing Engineering Education, University of Wisconsin-Milwaukee, 929 N Sixth St, Milwaukee, WI 53203. (414) 227-3125. June 10 to 12.

National Computer Conference, Chicago, IL. AFIPS, 1899 Preston White Dr, Reston, VA 22091. (800) 622-1987; in VA, (703) 620-8955. June 15 to 18.

ISDN, Atlanta, GA. Information Gatekeepers, 214 Harvard Ave, Boston, MA 02134. (617) 232-3111. June 15 to 19.

North Central Lightwave Expo, Minneapolis, MN. Lightwave, 235 Bear Hill Rd, Waltham, MA 02154. (617) 890-2700. June 16 to 18.

Satellite Communications (short course), Boston, MA. Continuing Education Institute, 21250 Califa St, Woodland Hills, CA 91367. (818) 710-1142. June 16 to 19.



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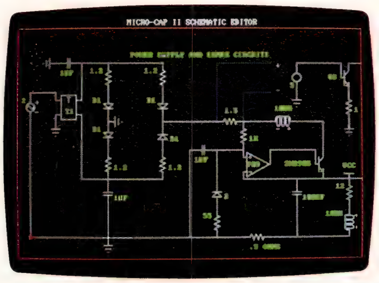
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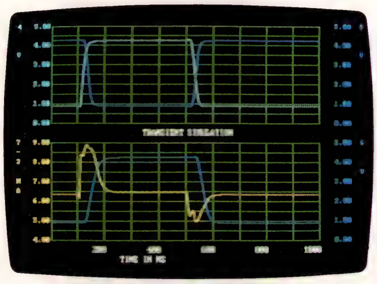

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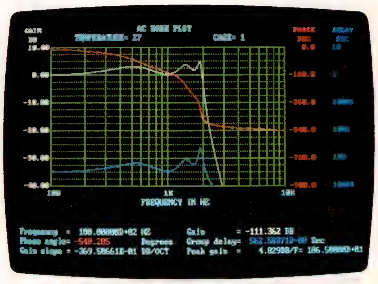

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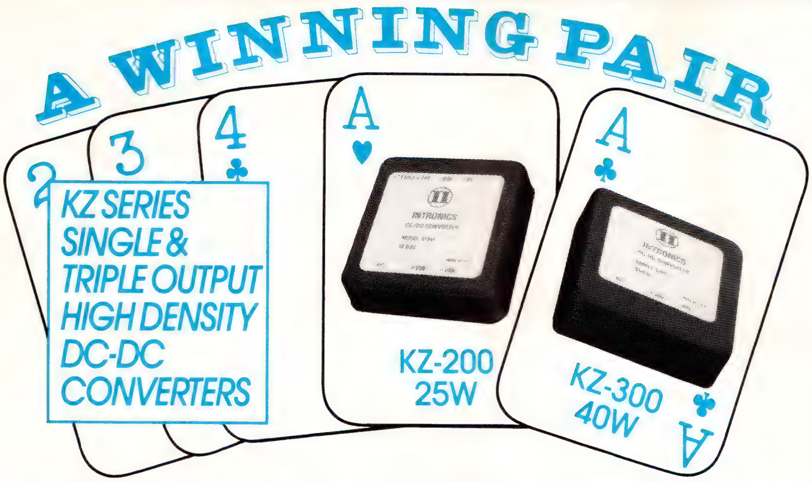

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CIRCLE NO 21

CALENDAR

Troubleshooting Microprocessor-Based Equipment and Digital Devices, Washington, DC. Micro Systems Institute, 73 Institute Rd, Garnett, KS 66032. (800) 247-5239. June 16 to 19.

Elexpo, Columbus, OH. Elexpo, Box 699, Utica, MI 48087. (313) 254-5310. June 17 to 18.

Effective Skills for Technical Managers (short course), Los Angeles, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. June 23 to 26.

Hands-On Programming in C, San Diego, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. June 23 to 26.

PC-Based Tools for Software Analysis and Design, Los Angeles, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. June 23 to 26.

Engineering for Electronics Production, Bloomington, IN. Dave Reece, Naval Weapons Support Center, Bldg 1, Crane, IN 47522. (812) 854-3666. June 24 to 25.

Design to Test (short course), Milwaukee, WI. Center for Continuing Engineering Education, University of Wisconsin-Milwaukee, 929 N Sixth St, Milwaukee, WI 53203. (414) 227-3125. July 7 to 9.

Directions and Implications of Advanced Computing, Seattle, WA. Computer Professionals for Social Responsibility, Box 85481, Seattle, WA 98105. Jonathan Jacky, (206) 548-4117, or Doug Schuler (206) 783-0145. July 12.

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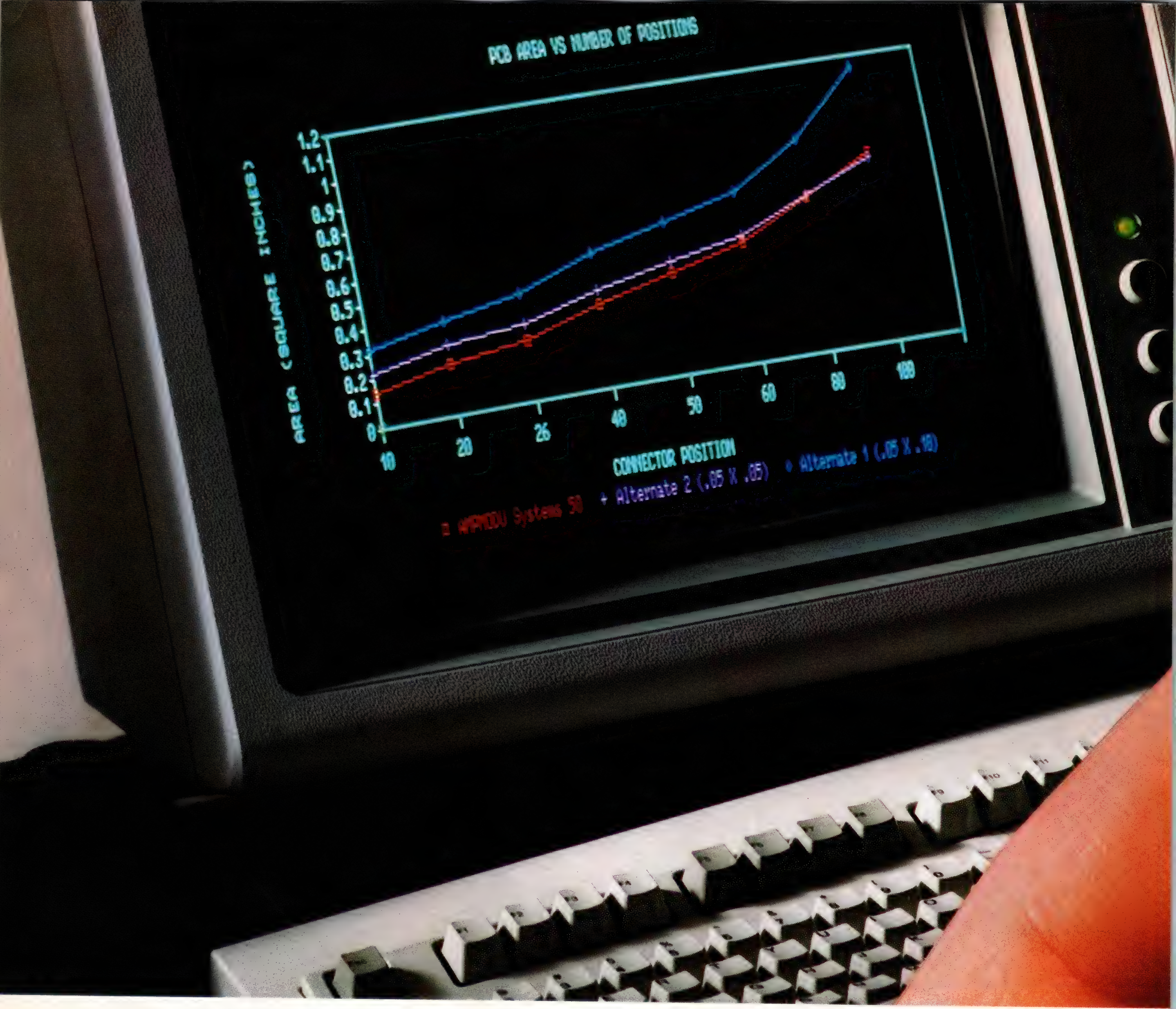
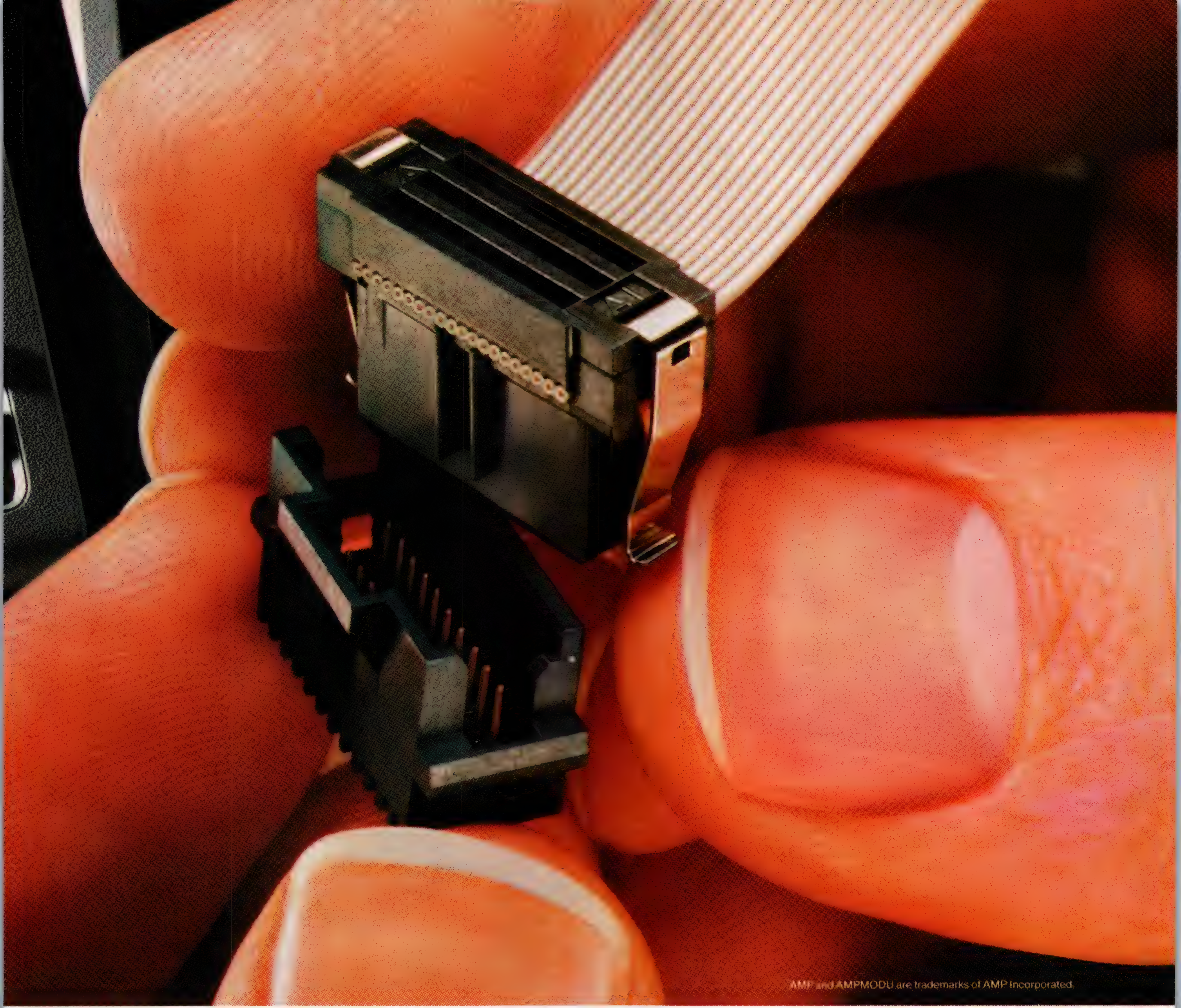


An idea this small is no small idea. Especially in a system this big.



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Along with selection, you also get the productivity features you expect from AMP: simple mass termination, robotic handling features, high-temp housings, selective gold plating. And, of course, outstanding quality and reliability.

AMPMODU System 50 connectors are available in 4 through 30 positions in single row configuration, 8 through 100 in dual row, with shrouded or unshrouded headers. With all those variations, you could do almost anything your heart desires. Which is the whole idea. **Call the AMP Product Information Center at 1-800-522-6752 and ask about our AMPMODU System 50 line. AMP Incorporated, Harrisburg, PA 17105-3608.**

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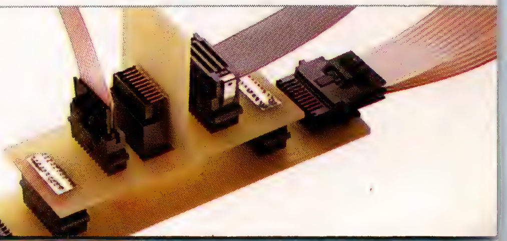
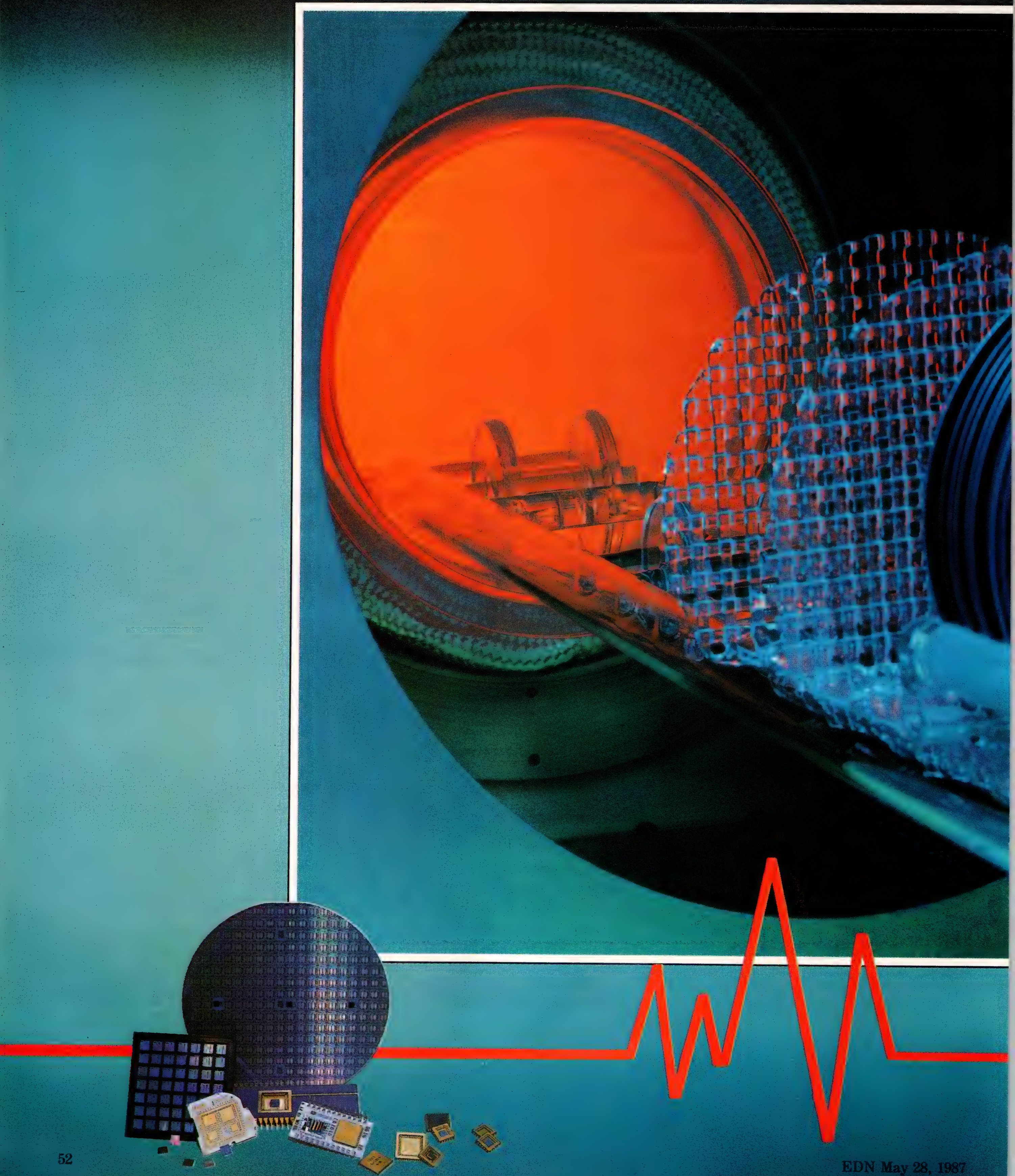
AMP Interconnecting ideas

Comprehensive high-density interconnect system: .050 x .100 connectors in a range of styles, to meet a variety of needs including board-to-board interconnect in both parallel and right-angle configurations.



Five good



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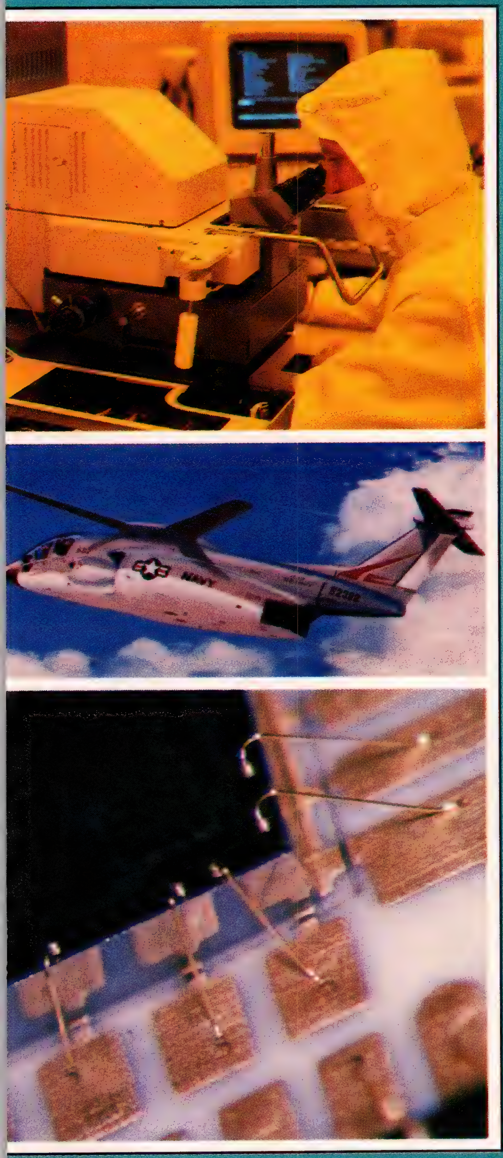

1. Our experience. We've been in the business of producing high-reliability electronic components for 14 years. In that time we've developed more than 20 capabilities — including full custom bipolar IC designs since 1975, custom bipolar wafer fabrication since 1976 and linear CMOS IC custom designs since 1980. Since 1984 we've added precision thin film resistors, DI design and fab, double layer metal and rad-hardened ICs, to name just a few recent landmarks.

2. Our high-rel certifications. In addition to MIL-STD-883C, we were one of the first 12 companies to attain certification to MIL-STD-1772 by DESC; we expect to have full 1772 qualification by mid-1987. And we're the only company with multilayer cofired ceramics capability.

3. Our technologies. Our CMOS IC technology includes a 3 micron and 5 micron process. Each has linear and digital standard cells available. Our bipolar technology includes 20V, 40V and 100V processes. Each can utilize dielectrically isolated wafers to eliminate parasitic interaction between devices. Often our ICs can replace many components, reducing manufacturing cost and overall size and weight while increasing performance and reliability.

4. Our resources. We have 10,000 square feet of Class 100 or better wafer fab clean room and 5,000 square feet of Class 100,000 microelectronic assembly clean room, housed in our 180,000 square foot facility. Of our 600 employees, 50 are devoted exclusively to Quality Assurance and 150 are engineers experienced in producing custom designs to customers' applications.

5. Our critical applications background. Although we are heavily involved in the most current high-rel applications, we earned our spurs as the leading designer and producer of cardiac pacemaker electronics. You can depend on a company that's used to delivering the highest levels of quality and performance.

Of course there are many more reasons to choose Micro-Rel for your full-custom ICs. But we hope these five will convince you that Micro-Rel is fully capable of satisfying your most demanding requirements. Reliably — and on time.

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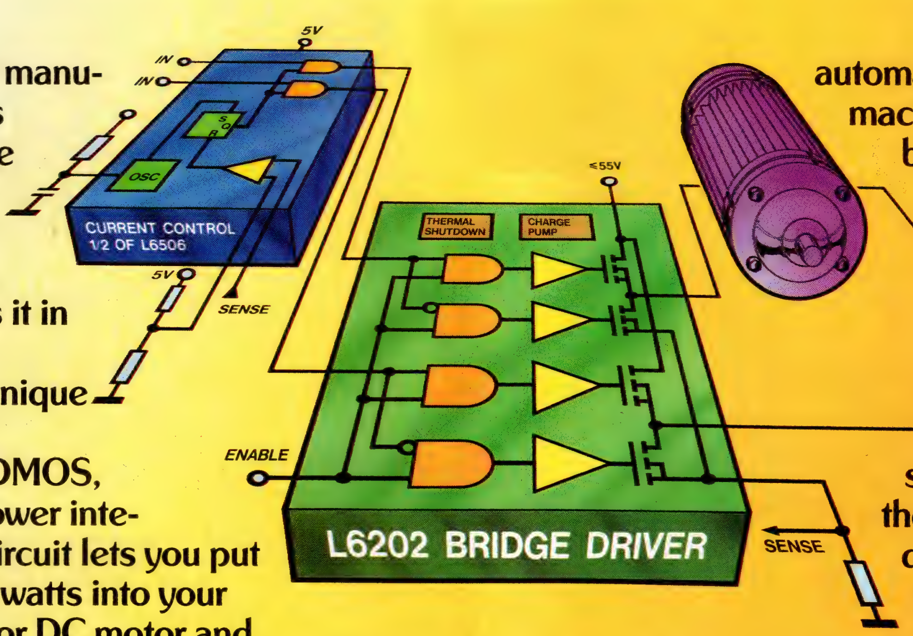
CIRCLE NO 136

A 1.5A/48V BRIDGE DRIVER THAT NEEDS NO HEATSINK. WHO CAN DELIVER?



Other manufacturers may have it on paper, but only SGS has it in stock.

This unique Bipolar/CMOS/DMOS, smart power integrated circuit lets you put a full 70 watts into your stepper or DC motor and control it directly from TTL, CMOS or even a micro.

The high efficiency of the DMOS output stage reduces on-chip dissipation to an extremely low level, so you can do away with heatsinks or costly forced air cooling systems. Think of the reduced assembly costs and increased reliability.

Then think about cutting assembly costs even further.

The L6202 comes in a standard outline DIP so you can use your regular automatic insertion machines. And by using 6 of the package pins as a dedicated heat path, a small area of the PCB copper dissipates the heat.

But that's not all. The L6202 Bridge Driver is just one of many ICs based on SGS Multipower-BCD technology. This unique smart power capability is bringing you a whole new generation of devices with improved performance levels and application potential.

Absolute Maximum Ratings

Imax	5A
Ron	0.3ohm
Irms	1.5A
Vs max	48V
Fswitch	200kHz

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SGS is present in Australia, St. Leonards, Tel: 02-4385388 • **Benelux**, Eindhoven (NL), Tel: 040-433566 • **Brazil**, São Paulo, Tel: 011-883-5455 • **Denmark**, Herlev, Tel: 02-948533 • **France**, Montrouge, Tel: 01-47460800 • **Hong Kong**, Hunghom, Kowloon, Tel: 03-644251/6 • **India**, New Delhi, Tel: 6414537 • **Italy and South Europe**, Assago (MI), Tel: 02-8244131 • **Japan**, Tokyo, Tel: 03-3788161 • **Korea**, Mapo (Seoul), Tel: 02-7167472/3 • **People's Republic of China**, Beijing, Tel: 507766 • **Singapore**, Tel: 482-1411 • **Spain**, Madrid, Tel: 01-7337043 • **Sweden**, Märsta, Tel: 0760-40120 • **Switzerland**, Grand-Saconnex (Genève), Tel: 022-986462/3 • **Taiwan-Republic of China**, Taipei Sec 4, Tel: 2-772 8203 • **United Kingdom**, Aylesbury, Tel: 0296-395977 • **USA**, Phoenix, Tel: (602) 867-6100 **West Germany**, Grafing bei München, Tel: 08092-690.

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THE BRIGHTER POWER

SGS' unique Multipower-BCD technology—that's integrated Bipolar CMOS, DMOS—has a lot more to offer. What other smart power IC technology lets you connect as many DMOS output power transistors as you need on a chip, in any way you like? None.

That's just one example of how smart SGS power really is. And the L6202 is just one of many SGS smart power products.

To get the full story on SGS Multipower-BCD technology plus full data on the L6202, call your nearest SGS sales office now.

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CIRCLE NO 137

Pixel Perfect

The difference is clear.

Infograph combines the unique features of its P100 graphics controller with the IBM* 591 AC Plasma monitor. Plasma technology requires no refresh scan or shift so images are sharp and flicker free. And since the working surface is flat, lines are straight and precise, making this an exceptional display for precision drafting and designing. Graphics and text are razor sharp. No fuzz. No swim. No flicker.

Star of the big screen.

The Infograph system gives you a 17.2 inch diagonal viewing area and high resolution—960 x 768. That's 737,280 individually addressable pixels (71.4 pixels per inch). With a 10,000 character display capability, it's an excellent tool for desk top publishing, spreadsheets or word processing. There's room on the screen to display the equivalent of six conventional CRTs simultaneously.

No big bulky box here. The screen's foot print is just 7.8 inches deep so it saves work space. And with a 110 degree viewing angle, it's an excellent device for group presentations.

A cure for terminal illness.

The 40,000-hour MTBF rating of the Infograph system is two to three times that of most CRTs. It holds up in demanding work environments and sensitive installations. Virtually no radiation is emitted. And since images are flicker free, eye fatigue is minimized.

This is an excellent display for today's sophisticated software packages such as: Autocad, Lotus 123, VIA PC, XYWrite and Ventura Publisher. A software toolkit is available for OEMs and systems developers which makes adaptation of new or existing systems straight-forward. The difference is clear.

Infograph, graphically superior.

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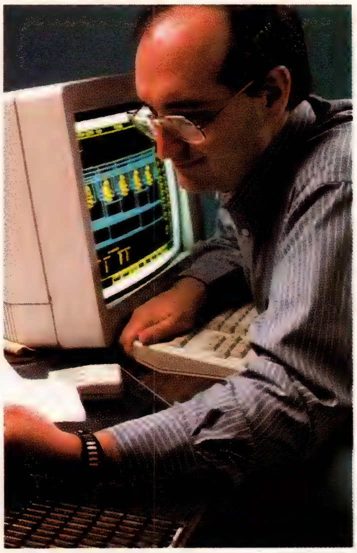
CIRCLE NO 138

SMT: Not too hot to handle



About once every 10 years, hardware-design engineers begin to latch on to a new technology that, at first glance, seems too hot to handle but eventually becomes pervasive. In the 1960s, integrated circuits were displacing discrete transistors from most designs. Electronic products built since 1970 usually contain several of these multilegged critters. The 1970s brought in the microprocessor, which dominates today's digital-product designs. This decade's equivalent—surface-mount technology (SMT)—promises to have an equal or greater influence on electronic-product design than did either the integrated circuit or the microprocessor.

Because of SMT, we will witness the demise and eventual disappearance of hand assembly and, consequently, a rise in product quality and manufacturing economy. SMT allows you to build today's design in a smaller, less expensive form, or you can add features to an existing design while maintaining the same package size. Although you can't obtain every component in a surface-mountable package—high-pin-count ICs and power devices are the notable holdouts—SMT-device availability improves almost daily. Large and small companies alike are not waiting for every device to become surface mountable. They have already made major commitments to SMT.

If you design electronic products or manage electronic designers, you should have a plan in place now to address how and when SMT will impact your products and your company. SMT, though a manufacturing technology, affects the tasks performed by design engineers, pc-board designers, manufacturing engineers, test engineers, and component buyers. Even stockrooms and finished-goods storage are affected because of the size reductions incurred by the use of technology. Be assured that your competitors, both domestic and international, will surely consider SMT (if they have not done so already), and a large percentage will embrace this technology—sooner than you think.

Steven H Leibson

Steven H Leibson
Regional Editor

Follow the

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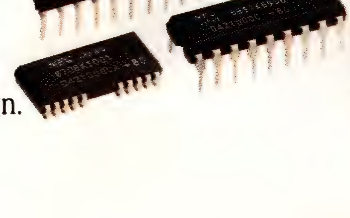
The time is ripe for your megabit move.

NEC announces the fastest 1 Megabit CMOS DRAM.

You waited till 1 megabit DRAM technology reached maturity. Now it's time to move. NEC, the world leader in memory production, gives you 80ns access time and CMOS technology in a 1 megabit DRAM. You can't find this high-capacity, high-speed, low-power combination anywhere else.

Why move up from 256K? Because now you get fourfold capacity with 25% less power consumption. Our megabit memories feature a 1.0μ CMOS process, 2-layer polysilicon wiring and trench capacitor design.



Choose from three families with 1-bit organization or two families with 4-bit organization. All give you three speed options: 80/100/120ns. And a wide range of packages: plastic DIP, ZIP and SOJ for surface mounting. Supply voltage is 5V ± 10%.

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Device	Organization	Speed	Mode	Package
µPD421000C	1M × 1	80/100/120ns	Fast page	18-pin DIP
µPD421000LA				26-pin SOJ
µPD421000V				20-pin ZIP
µPD421001C			Nibble	18-pin DIP
µPD421001LA				26-pin SOJ
µPD421001V				20-pin ZIP
µPD421002C			Static column	18-pin DIP
µPD421002LA				26-pin SOJ
µPD421002V				20-pin ZIP
µPD424256C	256K × 4		Fast page	20-pin DIP
µPD424256LA				26-pin SOJ
µPD424256V				20-pin ZIP
µPD424258C			Static column	20-pin DIP
µPD424258LA				26-pin SOJ
µPD424258V				20-pin ZIP

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NEC

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Get to the test mode

In fact, twice as fast.

If you're developing automated test routines for microprocessor-based digital circuit boards, we'd like to introduce you to the concept of speed. A concept that has been difficult and expensive to attain in emulative testers—until now.

Introducing the 9100A Digital Test System. It's a high-performance, totally integrated solution that accelerates software development, then boosts test and troubleshooting productivity far beyond anything else in its class.

And it's from Fluke, maker of the 9000 Series, the world's best selling digital troubleshooter. Of course.

Fast Programming

With the 9100A Test Programmer's Station, you can create powerful and detailed test software in half the time it takes with other emulative-type systems. Weeks instead of months. And, still accommodate changes and enhancements without missing a beat.

Easy-to-use software: The 9100A features a high-level programming language, syntax-checking editor and source-language debugger all designed specifically for writing digital test and diagnostic routines. And advanced Fluke hardware connections let you work interactively with your unit-under-test (UUT), speeding program verification.

Built-in decision tree: Enter the board information in straightforward database format. Add stimulus routines. The 9100A then produces comprehensive test programs for Guided Fault Isolation (GFI) almost automatically. A special fault-tracing algorithm makes all the choices about the troubleshooting sequence.

Fast Troubleshooting

Here's where Fluke's new system really takes off!

Because the programs you develop on the 9100A can be executed by any number of low-cost 9105A Digital Test Stations distributed wherever you need them—on the production line serving as functional testers, off the line troubleshooting fallout from your ATE, or in service.

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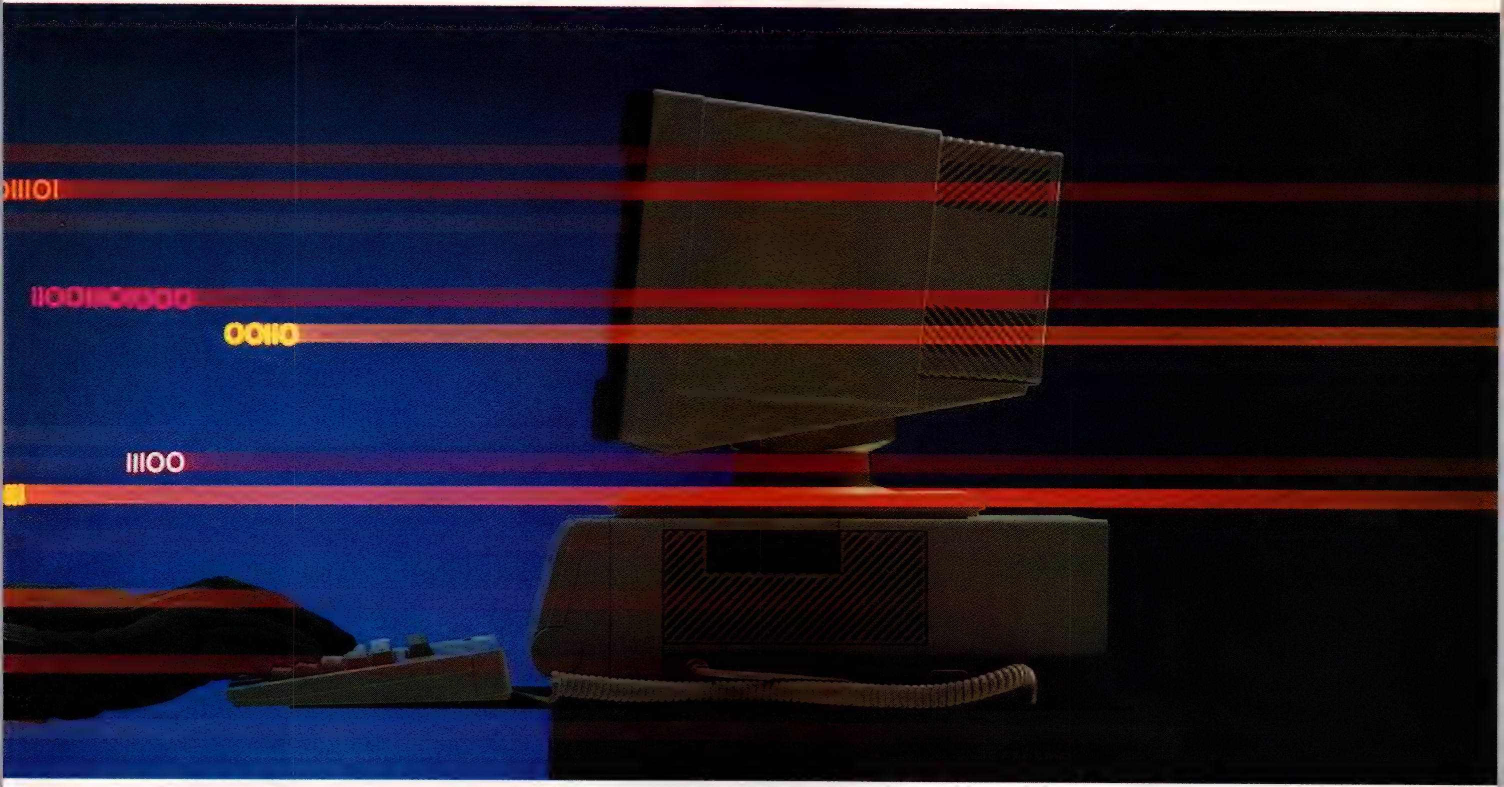

Full board coverage: This system isolates digital hardware faults down to the node level on all digital circuitry, SSI to ASIC, at rates up to 40 MHz. For virtually all boards (Fluke interface pods support real-time emulation of over 50 different microprocessors).

Automated Fault Isolation: Lightning-fast functional tests for elusive µP kernel faults are pre-programmed, and activated by simple keystrokes. Beyond the kernel, your GFI programs guide an operator right to the faulty node quickly, with diagnostics in plain English. Which means higher throughput with operators of all skill levels.

Advanced circuitry interface: New Parallel I/O Modules—a Fluke innovation—let you test as many as 160 pins simultaneously at up to 10 MHz. Helping to isolate faults faster than you ever thought possible. And fixturing is amazingly flexible, allowing clips, bed-of-nails, and board-edge connections.

For higher-frequency signals and those hard to reach nodes, the system also comes with a single-point probe.

High Performance Support

The 9100A Digital Test System is the latest in a long line of Fluke Board Test Equipment which includes the 3200B Manufacturing Defects Analyzer, 3050B Functional Test System and 9000A Micro-System Troubleshooter. And it comes with all the service, training and applications support Fluke is famous for the world over.

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HEXFET III protection like this lets you forget about zener clamping. And snubber circuits. And series diodes. And any other unnecessary protection components.

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Best of all, HEXFET III performance extends across our complete family of HEXFET power MOSFETs — from 60 volts to our new 1000-volt device.

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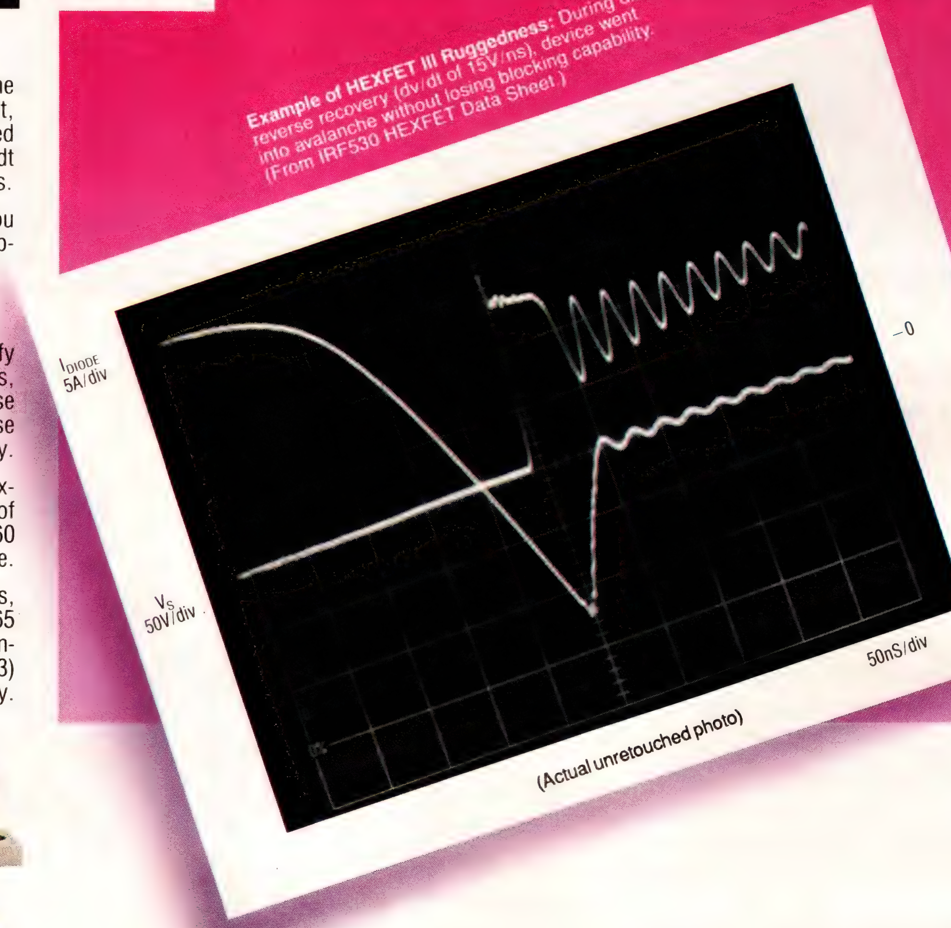
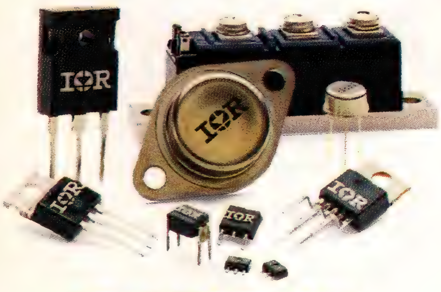


Example of HEXFET III Ruggedness: During diode reverse recovery (dv/dt of 15V/ns), device went into avalanche without losing blocking capability. (From IRF530 HEXFET Data Sheet.)

(Actual unretouched photo)



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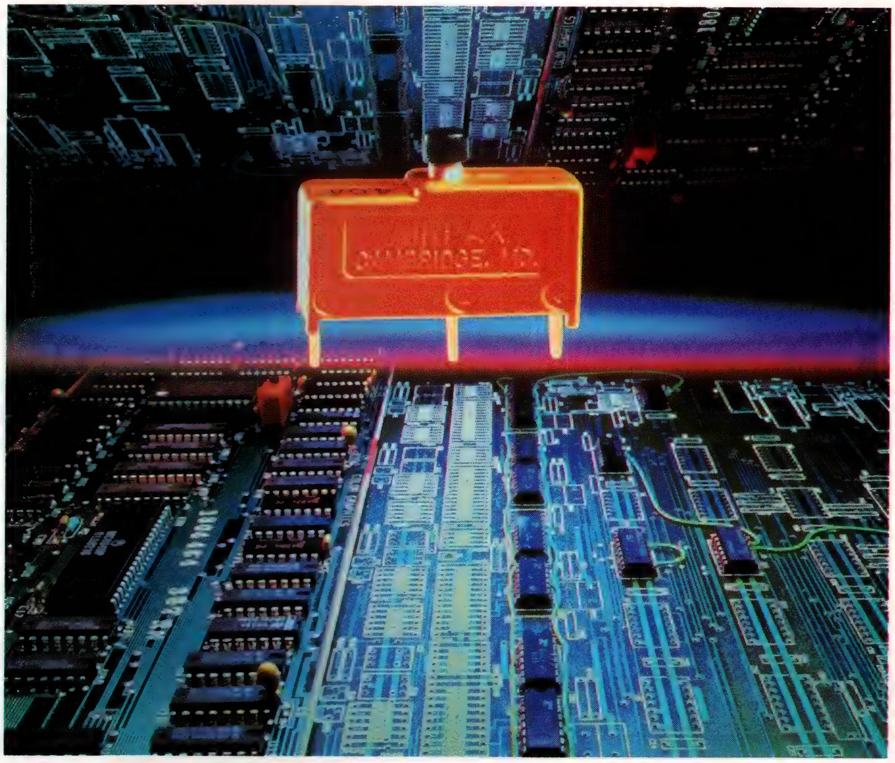
CIRCLE NO 141

TECHNOLOGY UPDATE

Today's circuit-protection devices provide needed board-level surveillance

Tom Ormond, *Senior Editor*



Available in versions suitable for vertical or horizontal mounting, *the thermal-type Cardgards from Airpax Corp can withstand most of the same chemical cleaning processes as other pc-board components.*

As pc boards continue to increase in circuit density and complexity, designers have an ever-increasing need to include circuit protection right on the boards themselves. Heat can play havoc with delicate integrated circuitry, so you'll find it helpful to monitor environmental conditions right at the pc-board level.

Fortunately, protection-device manufacturers have responded to this need with a number of current-limiting and voltage-monitoring products that employ a variety of sensing elements—thermistors, solid-state switches, reed switches, and thermostats. These products mount directly on a pc board yet incur minimal real-estate penalties.

Such protection devices monitor different parameters—current, temperature, voltage, and air flow—to directly or ultimately control current levels. Trip levels and trip speeds vary from device to device, so you can select a protective device that matches your specific needs.

A current-protection device with a fast-trip speed at slight overloads might be appealing if your board circuitry is particularly sensitive, but if your application involves rapid surge currents, for example, you might encounter false tripping. To avoid nuisance tripping, you could choose a device that acts only in response to a nearly total short circuit, but you should determine whether the delayed trip performance would place severe stress on your circuitry.

Thermal protective devices offer a compromise that might provide your application with adequate protection while minimizing nuisance trips. Airpax Corp's Cardgard circuit breakers are thermal-type current-sensing devices that measure approximately ¾×¼×½ in. and weigh only 1.8g. They mount directly on a pc board along with all the other components. Solderable terminals are available for either vertical and horizontal mounting to suit specific application needs. The devices sell for $2.75 (500).

Each Cardgard is a 3-terminal device. The line and load terminals provide the overload-sensing capability. When a Cardgard is in the on position, the line and load terminals are electrically connected, and the fault terminal is isolated. When the device trips into the off position (either from manual actuation or from an overload), the load terminal becomes electrically isolated, and the line terminal switches to the fault terminal. The fault terminal has a 6A rating, so you can use it to trigger an external alarm system.

Current ratings for the seven units in the Cardgard line range from 1 to 6A. Voltage ratings are 32V dc and 250V ac. The minimum trip point for all units is 160% of rated current, and interrupt capacity equals 10 times the rated current. The units are specified for 50 electrical operations at 150% overload current followed by 6000 mechanical trips at full rated current. They operate over the 0 to 40°C range.

Each Cardgard receives yellow-card recognition under the conditions of UL-1077. In addition, you

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- 0.001% distortion;
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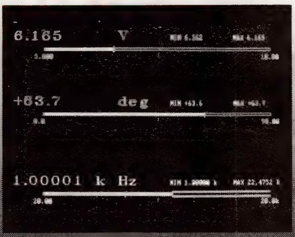
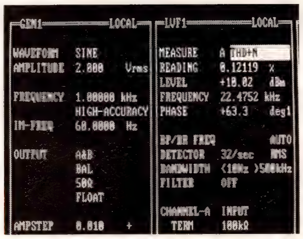
One keystroke displays analog bargraphs for tweaks; as many as three parameters measured and, displayed simultaneously.

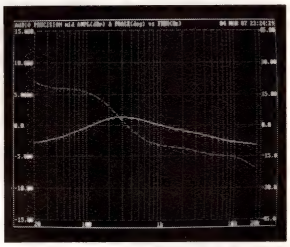


```
6.165         V
+63.7        deg
1.00001 k Hz       MIN 1.00000 k   MAX 22.4752 k
```



```
GEN1                LOCAL   LVF1                 LOCAL
WAVEFORM   SINE             MEASURE    A THD+N
AMPLITUDE  2.000     Vrms   READING    0.12119   %
                            LEVEL      +10.02    dBm
FREQUENCY  1.00000 kHz      FREQUENCY  22.4752 kHz
           HIGH-ACCURACY    PHASE      +63.3     deg1
IM-FREQ    60.0000  Hz
                            BP/BR FREQ           AUTO
OUTPUT     A&B              DETECTOR   32/sec    RMS
           BAL              BANDWIDTH  <10Hz >500kHz
           50Ω              FILTER     OFF
           FLOAT
                            CHANNEL-A  INPUT
AMPSTEP    0.010     +        TERM     100kΩ
```

One keystroke runs and graphs a test in seconds, measuring one or two variables versus frequency, amplitude, time.



Use mouse or arrow keys with on-screen panels to **make impromptu changes** in impedances, detectors, filters, levels, frequencies - or name and **save a complete setup to disk,** recall it with mouse or a few keystrokes.

```
AMPLITUDE BANDPASS BANDREJECT THD+N SMPTE CCIF DIM W+F 2-CHANNEL CROSSTALK
Measurement mode                               To select another field, use arrow keys.
```

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CIRCLE NO 78

can use the devices in equipment destined for the international market because they meet VDE and IEC requirements for installation in clean, dry (or otherwise protected) areas inaccessible to the operator. They are also certified to the requirements of IEC 664, insulation category 1, pollution degree 1, class A.

Although a Cardgard device can tolerate many of the same chemical cleaning processes as the other components on a pc board, Airpax doesn't recommend immersion cleaning. A reusable protective cover is available, however, to accommodate wave-soldering and flux-cleaning operations.

Meeting international needs

E-T-A is another manufacturer offering pc-board-mountable thermal-type circuit breakers. The Series 41-040-PR includes internationally approved devices that accommodate either vertical or horizontal mounting. They are UL recognized, CSA certified, VDE approved, and cost $2.60 (OEM qty).

Breaker operation is very similar to that of magnetic devices. A spring-loaded latching mechanism keeps the switch contacts closed until the current-sensing element detects an overload. Transient or short-duration overloads will not cause nuisance tripping. If an overload does occur, the latching mechanism will release, and the contacts will open. You don't have to worry about chatter or contact bounce.

You can't hold the breakers closed against overloads. Pressing the reset button results in a wiping action that resets the contacts and compresses the spring in the latching mechanism, setting it into the hold position.

Rated currents for this family range from 50 mA to 10A; tripping occurs at 140% of rated current. Maximum interrupting capacity is six times the rated current (3A or less ratings), five times (3.5 to 5A ratings), or four times (6 to 10A ratings). A unit's lifetime specification is 2000 cycles at the rated current.

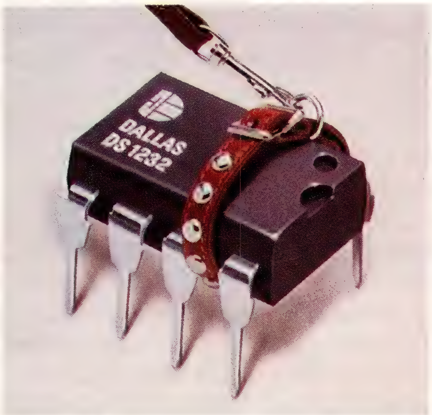
Maximum voltage ratings are 250V ac or 28V dc. Dielectric strength and insulation resistance equal 1500V ac and $10^8\Omega$, respectively. Maximum trip times vary with the rated current, ranging from 40 to 7 sec (200 to 600% of rated current) for units with ratings to 6A, and 25 to 6 sec (200 to 400% overloads) for 7 to 10A devices.

Avoid assembly problems

Although no one disputes the value of board-level circuit protection, not all manufacturers feel that it's wise to hard-wire circuit breakers directly onto pc boards. Heinemann is one such manufacturer. The company feels that contaminants resulting from the soldering and cleaning process may leak into the breaker housing and compromise the performance of the breaker.

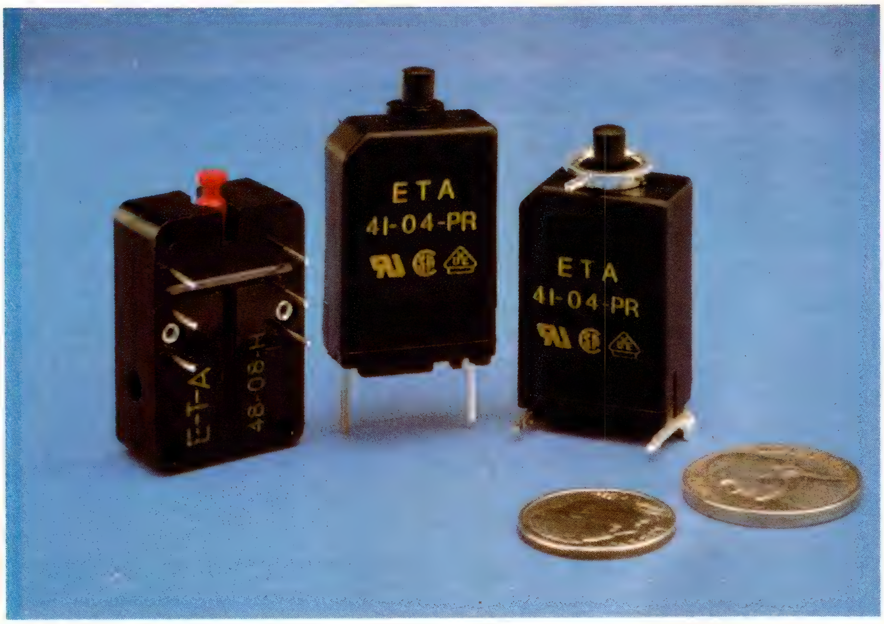
Rather than forsake board-level protection solutions altogether, Heinemann offers pc-board sockets, which allow you to insert and remove circuit breakers in seconds. The sockets are designed to accept the company's JA and JA/S breakers, which have current ratings varying from 10 mA to 30A, and they feature a snap-lock design that holds the breakers firmly in place. Their ¾-in. profiles accommodate narrow board spacings, and they sell for $1.50 (1000).

Breaker installation is quite simple. The breaker snaps into the socket, locks in place, and makes



Designed for µP monitoring, *the DS1232 from Dallas Semiconductor electronically checks a processor's power-supply level, external-override operation, and software-execution status.*

To help prevent damage to sensitive components on pc boards, *Warren G-V's SAF switches monitor and report on air-flow performance independent of ambient temperature.*



Housed in packages specifically designed for pc-board mounting, *the Circuit Savers from Inresco will trip at overloads in the 10 to 50% range.*

These VDE-approved circuit breakers, *the Series 41-04-PR sold by E-T-A, are trip-free and foolproof: You can't hold them closed against an overload.*

electrical contact. To remove the breaker, you simply press down on a tab at the rear of the socket, and the breaker pops loose. To re-install, you simply push the breaker into the socket again.

Thermostat uses spst switch

Airpax's miniature thermostats are well-suited for use on crowded pc boards (or other places where space is at a premium). Housed in the equivalent of 8-pin DIPs, the Series 6600 costs $5.20 (500). For thermal monitoring, you can configure them to switch on a visual or audible alarm signal, turn on or vary the speed of a fan, or completely shut down a system.

These thermostats feature an spst switch controlled by a positive snap-action bimetallic element. The switch's gold-plated contacts are rated for 1A at 48V dc (resistive) and are available in normally open or normally closed configurations.

The devices are compatible with automatic insertion equipment. Their body material carries a 94V-0 UL flammability rating, and their high-temperature epoxy seal withstands wave-soldering and board-washing operations.

Thermostat trip temperatures (preset at the factory and not field adjustable) range from 40 to 120°C in 5° increments. The devices specify contact resistance and bounce of 50 mΩ and 3 msec, respectively. Insulation resistance (at 500V dc) equals 20 MΩ.

Polymers help to monitor heat

Poly Fuse current protectors from Midwest Components are valuable in applications where voltage levels don't exceed 40V. The solid-state units change state in response to a rise in temperature that exceeds the built-in trip temperature.

The devices are made up of a polyolefin base and carbon granules, which combine to produce a homogeneous mixture, with nickel bonded to each side of a thin sheet of the polymer. The nickel acts as an electrical conductor and contact surface.

At normal operating currents (hold currents), the carbon granules are in physical contact with each other and form a very low-resistance path (as low as 16 mΩ) through the polyolefin. When the circuit current flow reaches the trip-current level, the polymer heats up and exceeds the switching temperature of

For more information . . .

For more information on the circuit-protection devices discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

Airpax Corp
Husky Park
Frederick, MD 21701
(301) 663-5141
TLX 6849138
Circle No 717

Dallas Semiconductor Inc
4350 Beltwood Parkway
Dallas, TX 75244
(214) 450-0400
Circle No 718

E-T-A Circuit Breakers
7400 N Croname Rd
Chicago, IL 60648
(312) 647-8303
Circle No 719

Heinemann Electric Co
Box 6800
Lawrenceville, NJ 08648
(609) 882-4800
Circle No 720

Inresco Inc
654 Ocean Rd
Point Pleasant, NJ 08742
(201) 892-5881
Circle No 721

Midwest Components Inc
Box 787
Muskegon, MI 49443
(616) 777-2602
TWX 510-394-4130
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Warren G-V
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the compound. At this temperature, the polyolefin begins to expand, separating the carbon granules.

The sharp decrease in low-resistance paths causes a large increase in resistance (exceeding 5 kΩ). Once power is removed, the polyolefin contracts, which allows the carbon granules to again make contact and re-establish the original low-resistance condition.

The 15 units in the Poly Fuse line spec trip currents ranging from 150 mA to 4A. A 0.5A version costs $0.50 (10,000).

If you need speed

If you're looking for very fast-reacting circuit protection, then consider the Circuit Saver unit from Inresco. These devices will operate in microseconds with an overload of only 10 to 50%, and they'll reset themselves once you remove the overload. Circuit Saver units are housed in packages specifically designed for pc-board mounting. Their positions can be dictated by circuit function because you need not access them for resetting.

A Circuit Saver uses a current-limiting approach to circuit-protection design. The quick response results from using a reed switch as the active element. Because a reed blade has very low mass and high permeability, it will respond very quickly to a change in magnetic field. By properly arranging the switches and coil, Inresco is able to manufacture devices that react to a relatively narrow overload range.

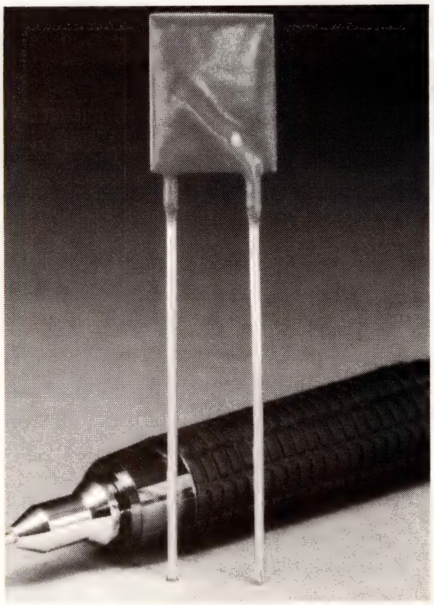
The inherent long life of reed switches ensures that the devices will respond to many more overload incidents than any equipment user would ever find acceptable for operation. Further, because the switch contacts are hermetically sealed, Circuit Savers can operate safely in flammable or explosive environments and aren't affected by dirt or corrosion.

Two types of Circuit Saver devices are available. Series 100 units cost $4 to $5 (1000) and come with ratings ranging from 10 mA to 1A. The devices respond in approximately 50 μsec. They operate on voltages of 5 to 15V dc, consume 15 to 50 mW at the rated current, operate over the −55 to +85°C range, and have a 100,000-cycle lifetime at rated current.

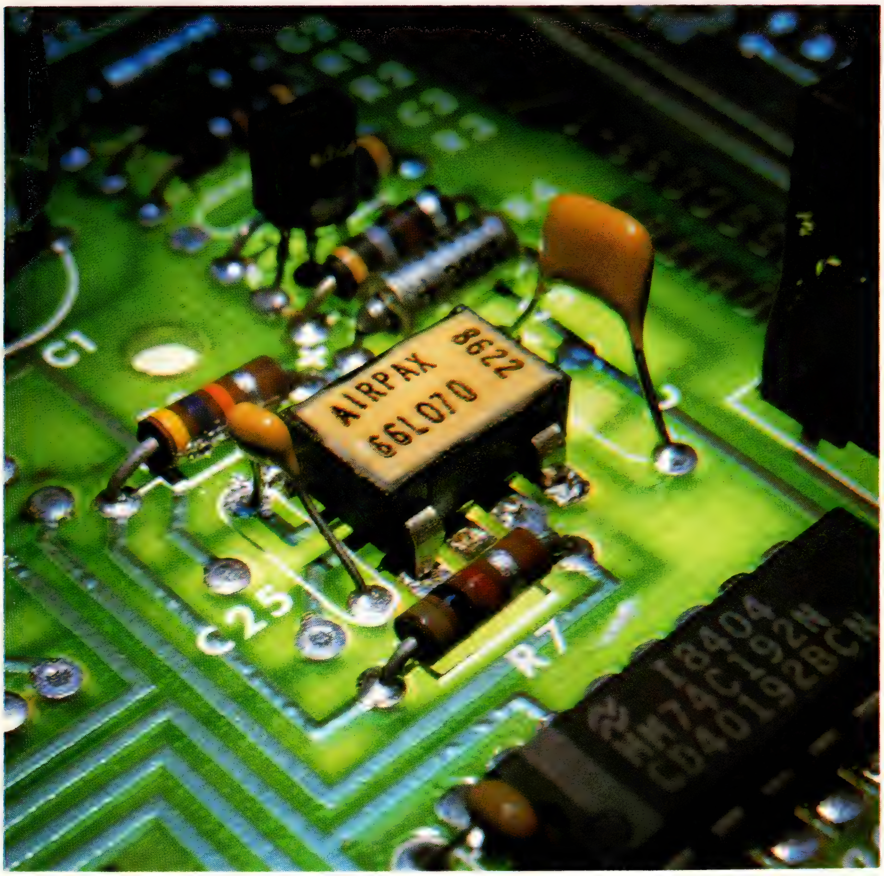
Series 200 Circuit Savers sell for $3 (1000) and are designed to protect circuitry in power-supply applications. They function as automatic current limiters, which prevent inrush current surges from damaging either the power supply or the load. When the power supply stabilizes, the Circuit Saver protects the supply from overloads initiated by the load circuits. These units come in pc-board-mountable packages.

Switch monitors air flow

Warren G-V offers the SAF Series of low-profile solid-state switches, which help prevent damage to heat-sensitive components on pc boards. These self-contained switches monitor and report on air-



Well-suited to applications where voltage levels don't exceed 40V, *Midwest Components' Poly Fuse current monitors switch into a protective state when the temperature exceeds the rated trip value.*



Operating as thermal monitors, *Series 6600 thermostats from Airpax can turn on indicator lights, alarms, and fans; send messages to a display; or even shut down a system.*

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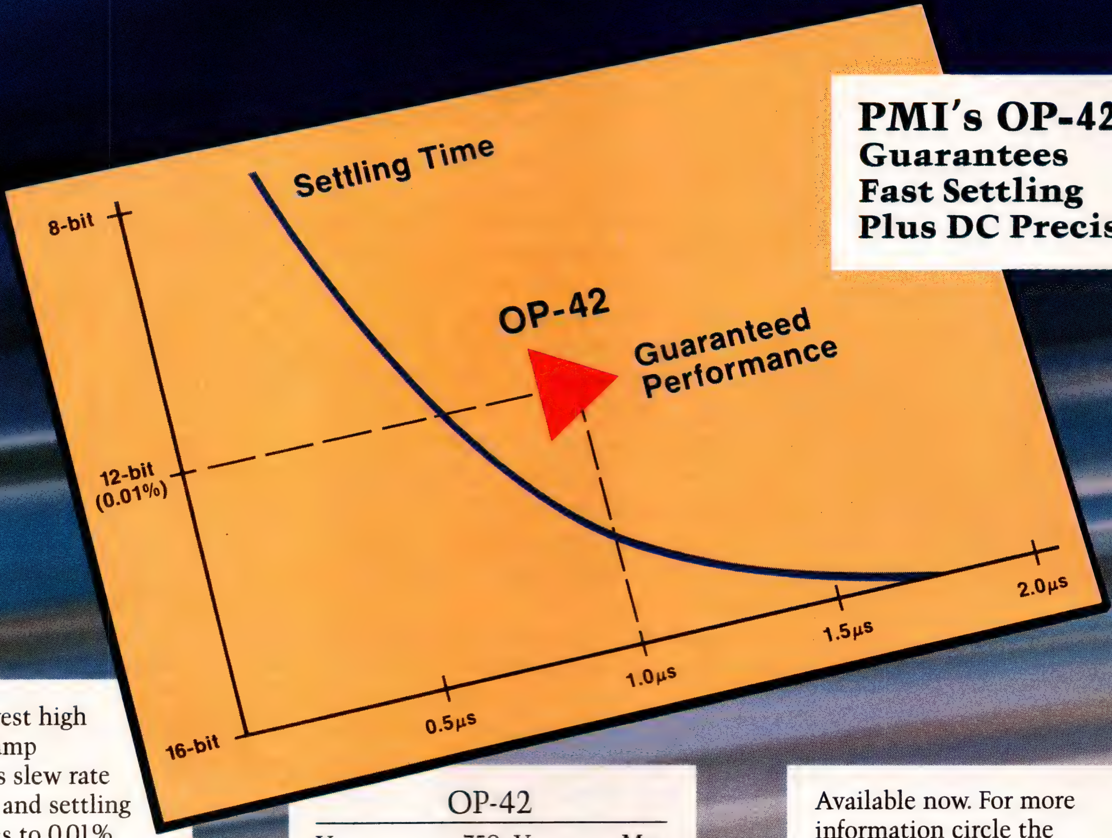

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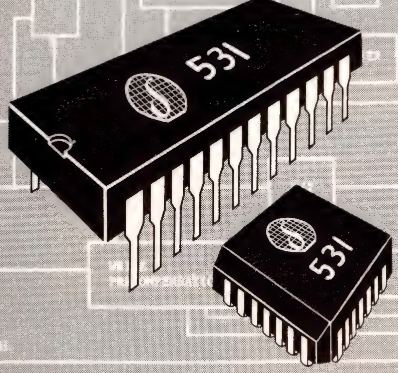

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- +5V operation
- 24 pin PDIP and 28 pin PLCC

The new SSI 531 Data Separator performs Read Data synchronization and Write Data precompensation for MFM encoded systems. The interface of the 531 has been optimized for use with the WD1010/WD2010 family of hard disk drive controller devices. Integrated into the unit is a high performance Phase Locked Loop (PLL) for data synchronization, a crystal-controlled reference oscillator for Write Data synchronization, and a write precompensator circuit that eliminates the requirement for an external delay line.

The 531 has been developed in an advanced bipolar process for precise bit cell control, resulting in reduced system sensitivity to bit jitter and superior error rate performance. It operates from the +5V power supply, and it is priced under $10 in OEM production quantities.

For more information, contact: **Silicon Systems,** 14351 Myford Road, Tustin, CA 92680. **(714) 731-7110,** Ext. 575.

silicon systems
INNOVATORS IN INTEGRATION

CIRCLE NO 22

flow conditions independent of ambient air temperature. Their open-collector outputs can sink as much as 100 mA to ground from sources ranging to 30V dc, so you can use the circuit-protection devices to control logic circuitry, relays, LEDs, and incandescent lamps. They are priced at $15.95 (100).

In operation, the units use a heated thermistor to sense the airstream velocity. The velocity affects the thermistor's temperature and therefore has an effect on its electrical resistance. Configured as part of a bridge circuit, the thermistor compares its resistance value against a reference circuit, thereby determining the air-flow velocity. When the air flow drops below the rated velocity, an SAF unit will switch and trigger the output load.

Members of this switch family are rated to monitor air-flow velocities of 50, 100, 250, 500, 750, 1000, and 1500 ft/minute. Custom air-flow settings are available on request. The setting tolerance equals ±25 ft/minute or 10%, whichever is greater. The operating range spans 0 to 50°C.

Designed for easy mounting in card racks with boards spaced on 0.625-in. centers, the switches come in TO-3 type packages. Two flange holes facilitate socket and bracket mounting in the main air plenums. The switches operate from a 5V supply source, dissipate approximately 0.5W, and feature an open-collector npn output transistor whose emitter is connected to ground.

Device keeps track of μPs

Dallas Semiconductor's DS1232 Micromonitor electronically checks three vital μP operating conditions: power-supply level, software execution, and external override. It holds the μP in check during power transients and halts and restarts an out-of-control processor. Housed in a space-saving 8-pin miniature DIP, the DS1232 also automatically restarts the μP after a power failure.

The $3.60 (100) Micromonitor uses a precision temperature-compensated reference and a comparator circuit to monitor the μP's power-supply level. When the voltage level falls below a user-programmable −5 or −10%, the DS1232 assumes that a power-fail condition exists and generates an internal power-fail signal. The Micromonitor maintains the reset signal for at least 250 msec after V_{CC} returns to an in-tolerance state to ensure that all parameters have stabilized before it releases the processor.

To monitor software execution, the DS1232 uses a watchdog timer to monitor a software checkpoint for routine behavior. If it receives no alert within a prescribed length of time (user programmable for 0.1, 0.5, or 1 sec), it assumes the processor is out of control and mandates a reset.

Although the DS1232 can monitor a processor's vital signs with no human intervention, you can also electrically connect it to an external pushbutton. The device will debounce the switch closure and generate a 250-msec reset pulse. If an operator notices a mechanical problem with a system peripheral, he can push the reset button, and the Micromonitor will develop the proper signals to restart the processor.

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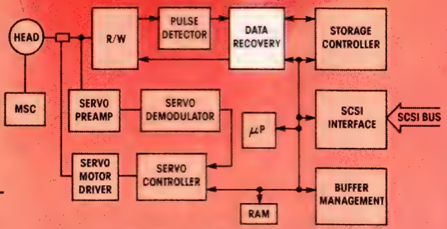

For mass storage disk drive electronics—Silicon Systems supports you best with total "head to host" IC solutions. Example: the Silicon Systems Data Recovery IC family. The flagship of this exciting new series is the SSI 532—the industry's most advanced single chip solution integrating data synchronization and ENDEC functions. Designed as a companion device to the SSI 452 and AIC 010 families of controllers, the 532 is destined to become the industry standard. And for good reason: it offers the type of raw performance and exclusive enhancements that really can separate your hard disk drive from the rest.

Just look at what this space-saver offers: 2,7 RLL encoding/decoding; window symmetry control with μP port for enhanced HDD testability; internal timing elements with a single external resistor to set the data rate; a precision decode window without the requirement of an accurate 1/4 cell delay; 15Mbits/sec. operation; fast acquisition PLL; plus a host of other dynamic features that will give your product the competitive edge.

But the SSI 532 is just one chip in Silicon Systems family of five Data Recovery IC's. Each is optimized for a specific type of drive—one is right for your type of drive. In addition to data recovery, Silicon Systems also offers broad IC families to cover virtually all other functions in HDD and FDD disk drive electronics.

For more information on the SSI 532 and other exciting product families in the SCSI chip set, contact Silicon Systems today.

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Circle 23 for career information

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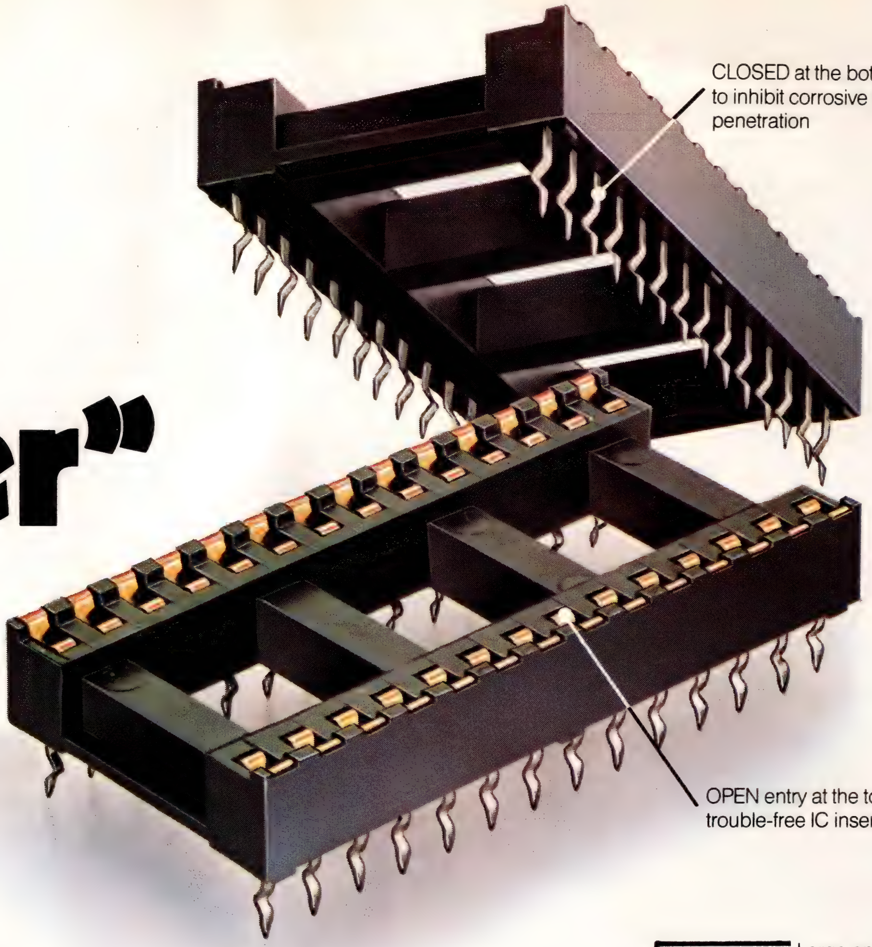

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OPEN entry at the top for trouble-free IC insertion

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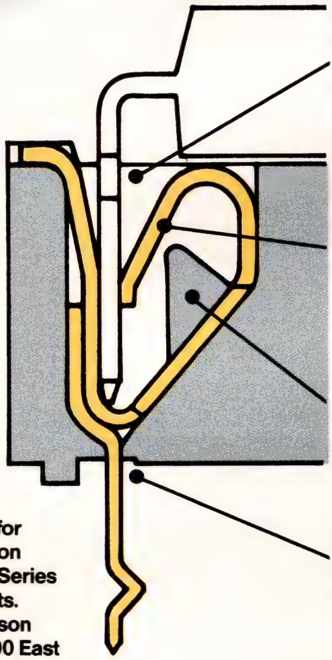

Large open entry target area for high speed automatic IC insertion.

Dual wiping contacts for high compression, gastight reliability.

Anti-overstress design prevents contact damage.

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WRITE TODAY for complete data on these low cost Series ICO/ICB sockets. Contact: Robinson Nugent, Inc., 800 East Eighth St., New Albany, IN 47150. Phone: (812) 945-0211.

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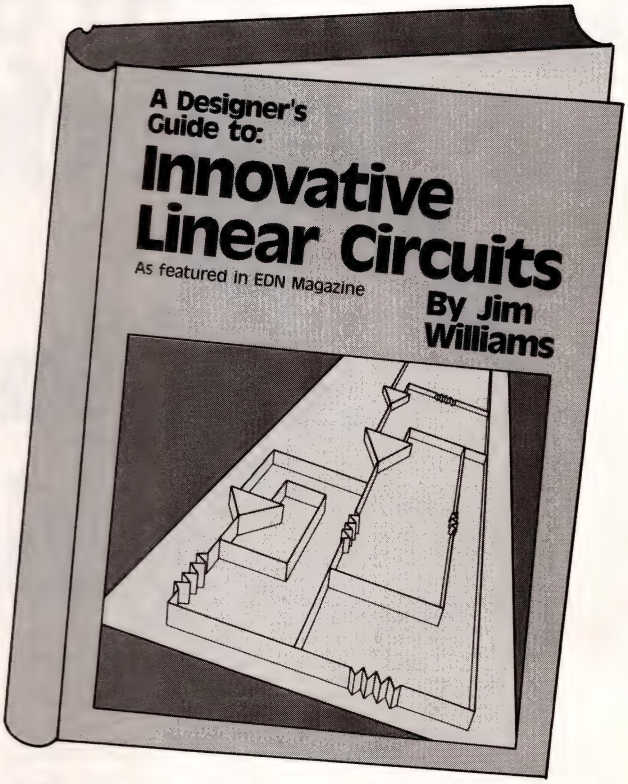

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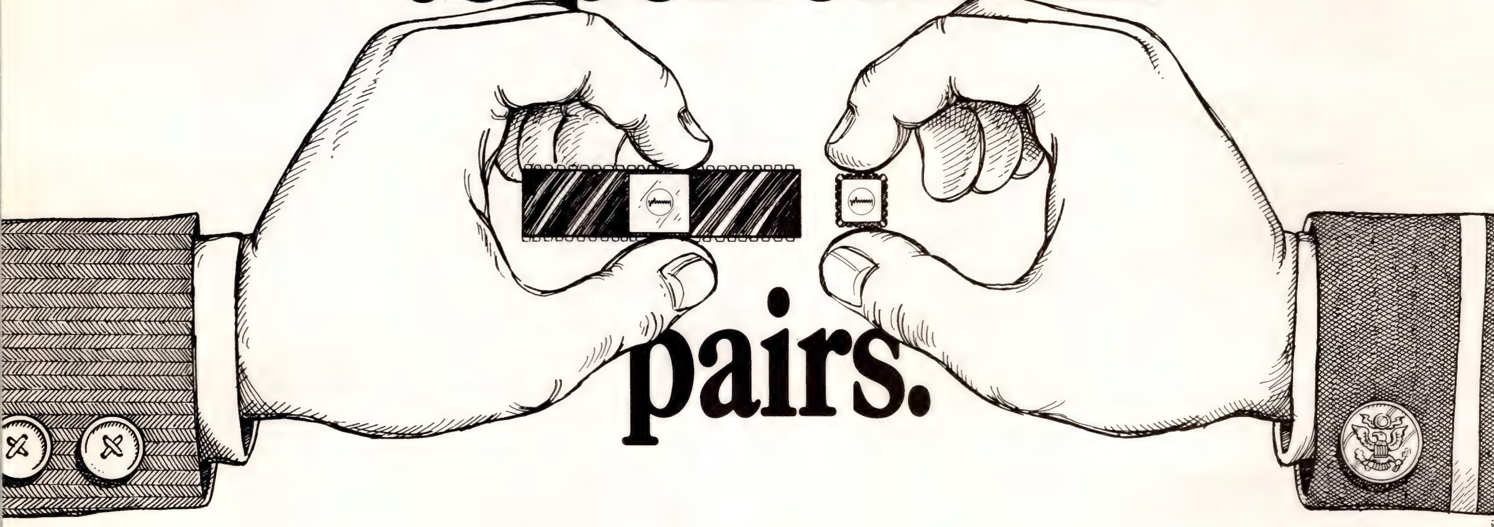

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Smaller, cheaper silicon pressure sensors are starting to appear on vendors' shelves

Chris Everett,
Regional Editor

Steady advances in the manufacture of silicon-based sensor ICs have enabled vendors to produce smaller parts. These new fabrication processes also eliminate the extensive individual handling that sensor ICs have usually required during the production process. The happy result of this bulk production is dramatically lower prices. But though more off-the-shelf sensors—especially pressure sensors—are becoming available, the majority of sensing applications in the near future will continue to be met with custom parts. Packaging constraints remain the primary reason for choosing a custom part.

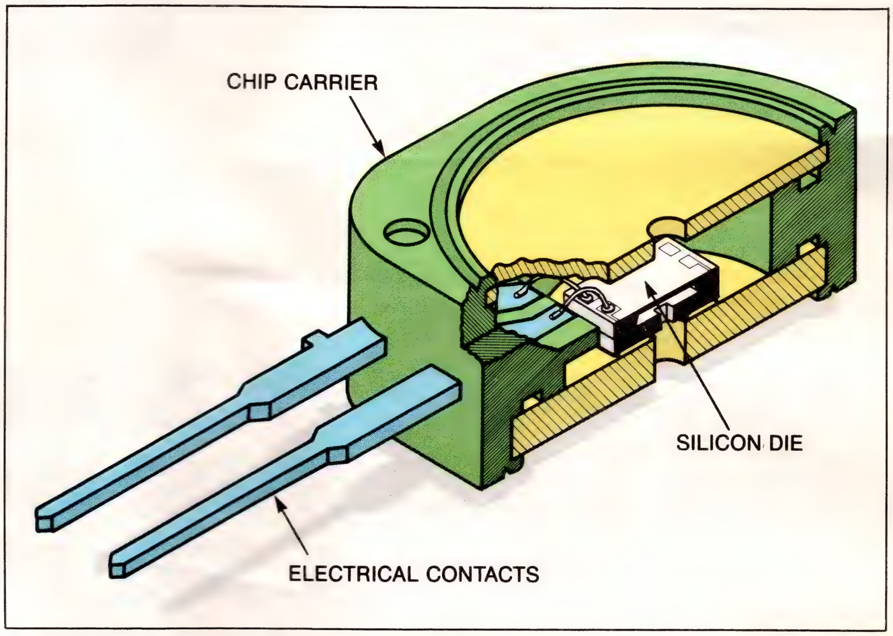

Fig 1—The chip carrier package doubles as the sensor package *for Sensym's SX sensors. You can seal the package with an O-ring onto a pressure fitting in your system.*

The virtues of silicon in the manufacture of pressure sensors are by now well known. Though it is brittle, it is very resistant to mechanical stress. It does not stretch and remain deformed like steel. Silicon can withstand pressures greater than 50,000 psi and accelerations as high as 100,000g. If you keep the stress levels below the elastic limit, the silicon will remain strong even under repeated cycling of tension and compression. Because silicon has this near-perfect elasticity and repeatability, silicon sensors can maintain measurement accuracies of better than 0.1% over periods of many years.

Pre-1970s pressure sensor diaphragms consisted of a thin silicon disk bonded to a metal constraint. Strain-gauge resistors for the Wheatstone Bridge were diffused onto the disk. Pressure on the diaphragm would stress one of the resistors, causing a change in the Bridge's output voltage.

The sensitivity of the pressure sensor depends on the thickness of the silicon diaphragm—the thinner the diaphragm, the more sensitive the sensor is to low pressures. To build a low-pressure sensor, engineers used to mechanically mill, or machine, a cavity into the diaphragm to thin it; the machining was followed by a chemical etch. In the mid-1970s, manufacturers turned entirely to a chemical-etching process, also known as micromachining.

The initial micromachining techniques employed isotropical etching processes. Because an isotropical etchant eats away at the silicon in all directions at the same rate, the resulting cavity has rounded corners. These rounded corners made it difficult to position accurately the strain-gauge resistive elements relative to the stress/strain region of the diaphragm.

An anisotropical etch, on the other hand, is orientation dependent. It etches at different rates in each of the three atomic planes defined by the silicon's crystalline structure. This variable etching rate allows the manufacturer of silicon pressure sensors to create well-defined walls, edges, and corners in the silicon.

An enhancement of these micromachining techniques was the use of doped impurities in the silicon to control the rate of etching, or even to act as an etch stop. For example, to machine the pressure sensor diaphragm, the manufacturer would heavily dope the front of a silicon wafer and then etch the rear of the wafer with an anisotropic etchant. This technique can yield diaphragms that are only a few micrometers thick.

The elimination of mechanical machining marked a revolutionary advance in the fabrication of silicon pressure sensors; since then, refine-

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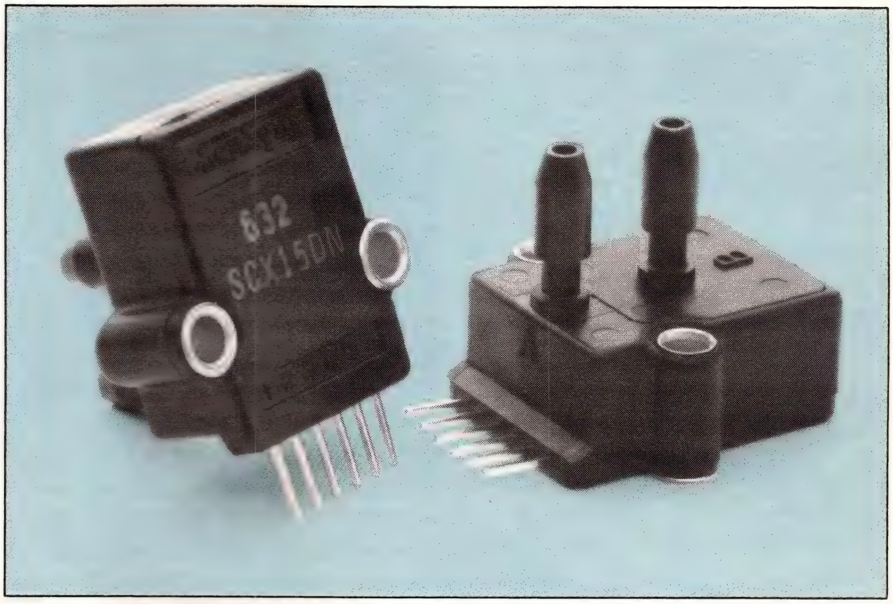
CIRCLE NO 99

ments have steadily brought sizes and prices to where they are today. By comparison, mechanically machined sensor diaphragms have diameters greater than ⅛ in. Today, chemically machined diaphragms measure 10 mils and less in diameter. A manufacturer can produce about 1000 diaphragms on a 4-in. wafer. And because manufacturers can now produce the diaphragms in bulk, rather than devote extensive attention to each individual sensor element, sensor prices have dropped from $60 five years ago to as little as $5 today.



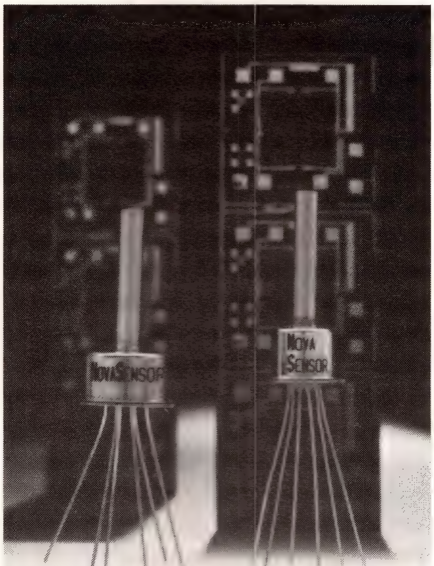
Designed to provide accurate, stable outputs over a 0 to 70°C range, *Sensym's SCX Series compensated pressure sensors are calibrated for span to within ±1%. These absolute, differential, and gauge sensors measure pressure in ranges from 0 to 1 psi to 0 to 100 psi.*

Lower prices depend on needs

One of the few families of pressure sensors that's currently available off the shelf is Sensym's SCX line of precision-compensated devices, which range in price from about $25 to $31. They are designed for applications that require high-accuracy measurements over large temperature swings. Absolute, differential, and gauge models ranging from 0 to 1 psi (0 to 7 kPa) to 0 to 100 psi (0 to 700 kPa) are available. (You'll often find pressure ranges specified in kilo-Pascals, or "kPa"; the specific formula for converting from pounds per square inch is 100 psi=689.48 kPa, but you'll see considerable rounding in the figures manufacturers give.) All the SCX parts spec a zero offset of 0V±300 μV, a span calibration of 90 mV±1%, a span temperature error of ±0.2% FS, and an offset temperature error of ±100 μV.

If you don't need the high accuracy of the original SCX Series, or you are willing to provide the external circuitry for fine adjustments of the zero point and the span calibration, you may want to turn to the C versions of the parts, which cost about two-thirds the price. For example, the precision-compensated SCX01 1-psi sensor costs $31.40, while the compensated SCX01C unit costs $20. The zero-offset spec for the C units is 0V±1 mV. The span calibration is ±5%, the span temperature error is ±0.4% FS, and the offset temperature error is ±0.2 mV.

If you don't need a calibrated or compensated sensor, you may find that a sensor from the lower-cost SX Series meets your needs. The SX 1-psi model costs $15, for example.



The use of standard packages, such as TO-8 and TO-5 cans, *keeps the price down for these gauge and absolute pressure sensors from NovaSensor. The sensors are pc-board compatible and can withstand the hazards of moist air.*

All the sensors in the SX Series use high-impedance 4.65-kΩ resistors in their bridges, making the sensors well suited to portable, low-power, or battery-operated systems. SX Series sensors cover the measurement ranges 0 to 1 psi to 0 to 100 psi.

Your choice of sensor packages

The SX Series gives you a choice of two sensor packages. If you plan to connect the sensor to the pressure source with tubing, you can use the glass-filled nylon single-in-line package (SIP) with tube ports. You can directly mount the SIP onto a pc board. If you want to integrate the sensor directly into your system, you can use the basic sensor package, which you can epoxy or clamp to a pressure fitting **(Fig 1).**

Other common sensor packages are the ubiquitous TO-8 and TO-5 cans. One off-the-shelf family that's available in these cans is NovaSensor's Nova PH Series. If you want to use your own sensor package, however, you can buy the sensor element alone or purchase it already mounted on a substrate with laser-trimmed temperature-compensation resistors.

The Nova PH Series comprises 5- and 15-psi gauge and absolute sensors. The uncompensated sensors cost $10 to $12 (OEM qty). NovaSensor provides you with the resistor values to build the external circuitry needed to set the zero-offset voltage and the full-scale output voltage, and to provide temperature compensation. The company will soon expand the Nova PH family to cover pressure ranges from 0 to 0.75 psi to 0 to 750 psi.

Substrate is the package

If you don't need 10,000 pieces (NovaSensor's minimum order size), you'll have to look elsewhere. IC Sensors' HIT Series sensors offer similar specs, but their packaging scheme is different from that of other sensors. Specifically, the substrate that holds the sensing element is itself the package. The substrate also has the interconnection pins and pressure ports attached directly to it.

The HIT Series includes gauge, differential, and absolute pressure sensors that take measurements over the 0- to 2-psi to 0- to 100-psi ranges. Prices for some of the devices go as low as $5 to $6 (OEM qty). It's worth noting that several of the models are electrically compatible with sensors in the Motorola MPX product family, with Sensym's SPX/SX products, and with Micro Switch's 134PC/137PC products.

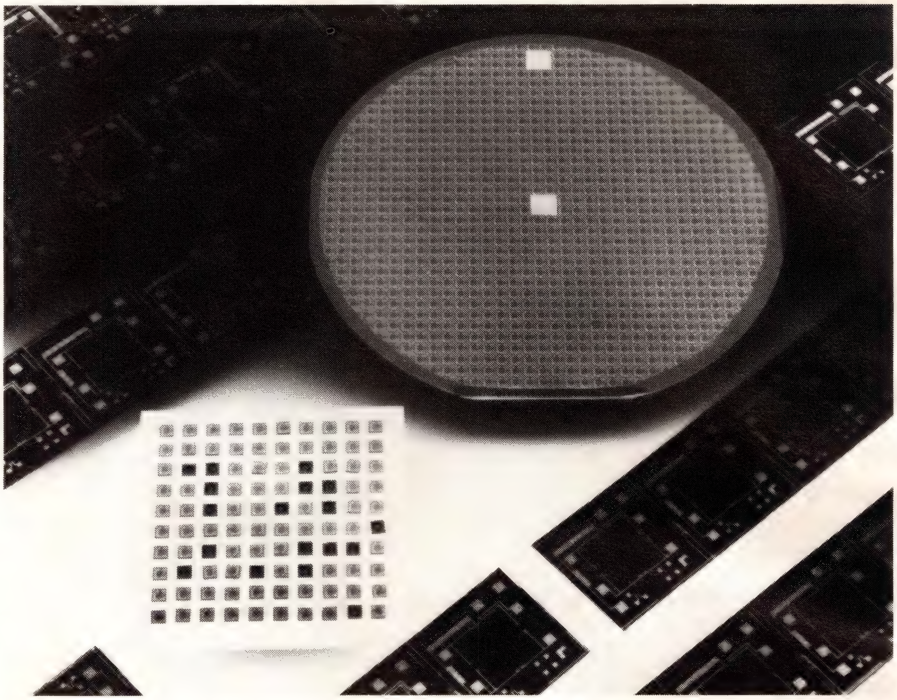
Several HIT Series sensors can take pressure measurements of corrosive liquids and moist air. You can order sensors with or without temperature compensation, span normalization, and interchangeability. Also, you can choose between two accuracy grades. The class-A sensors feature a ±0.1% FS linearity spec and a ±0.02%/°C temperature-compensation coefficient. The lower-cost class-B sensors feature a ±0.25% linearity spec and a ±0.04%/°C temperature-compensation coefficient. (For some caveats about linearity, see **box,** "Linearity definition varies among vendors.")

IC Sensors was able to lower the price of its HIT Series devices by minimizing packaging costs. Micro Switch uses the tape-automated-bonding (Tab) manufacturing technique to streamline the production of, and thus drive down the costs of, its 16PC pressure sensors (see **Ref 1**). The assembly technique also yields a true wet-wet differential sensor. Because the sensor's die is held in place by elastomer seals, which are in direct contact with the silicon, it was an easy step to move the bonding pads and components away from the diaphragm and seal the pressure ports to the area immediately around the diaphragm. Therefore, the bonding pads, bond wires, and other circuitry are isolated from the pressure medium. The only material a corrosive pressure medium could adversely affect is the material in the ports (polyester), the silicon diaphragm, or the elastomer seal material (fluorosilicone).

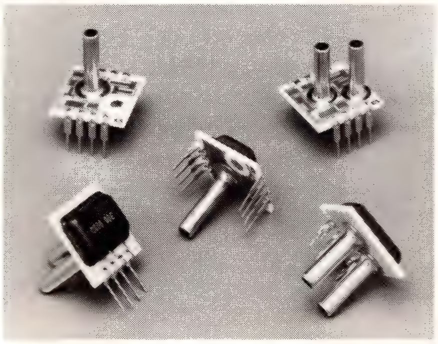
The 16PCD differential pressure sensors are available in three operating ranges: 0 to 5 psi, 0 to 15 psi, and 0 to 30 psi. The zero offset is 0V±2.0 mV, and the sensitivity shift is ±3.0% FS. The devices in this family cost $16.64 (500).

Integrating other circuitry

Because the same standard photolithographic processes are used to machine sensors as to manufacture ICs, you'd think that it should be an easy step to build sensors on the same die with a microprocessor, or to add all the compensation and sig-



Your choice of the basic pressure-sensor chip *or the chip mounted on a substrate with laser-trimmed temperature-compensation resistors gives you the packaging flexibility you need to tailor these NovaSensor devices to a wide variety of applications. Bridge-resistance values of 200Ω through 15 kΩ are available.*



The substrate is the package for these pressure sensors *from IC Sensors. Absolute, differential, and gauge sensors take measurements over 0- to 2-psi to 0- to 100-psi ranges. You can order several options, including low or high impedance, integral temperature compensation, span normalization and interchangeability, and various lead and tube combinations.*

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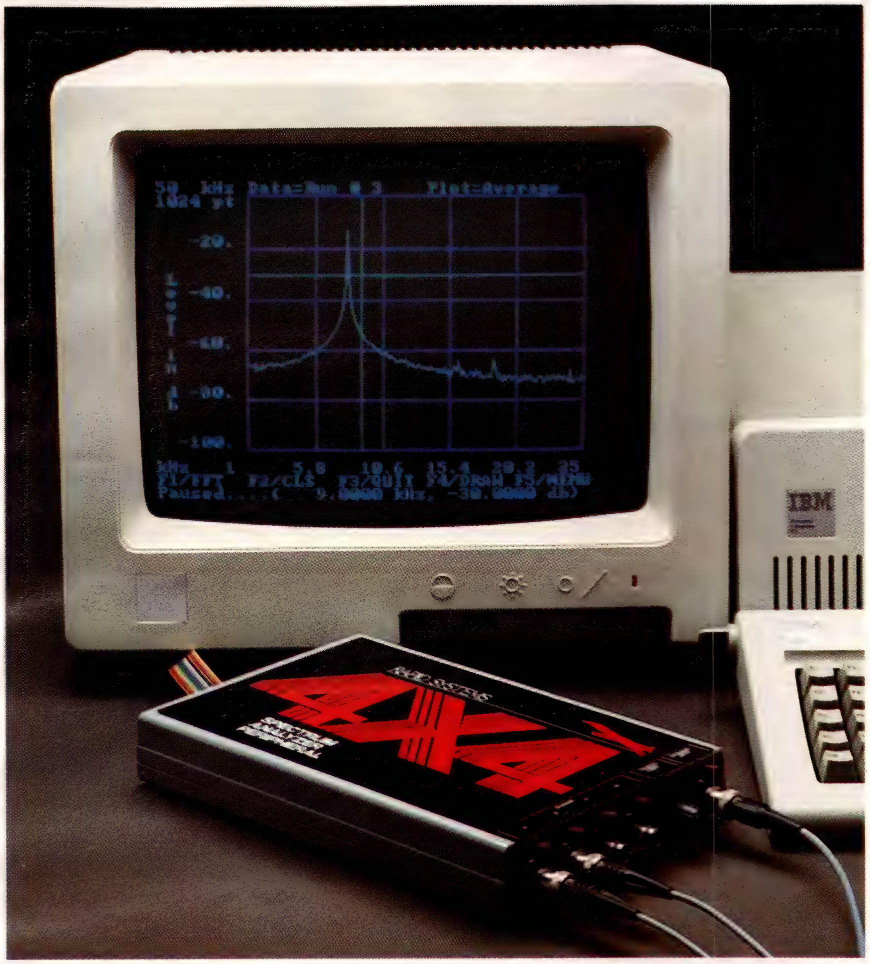

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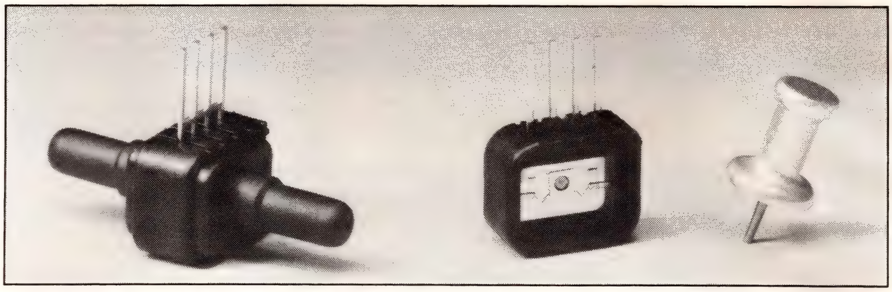
CIRCLE NO 100

nal conditioning circuits to the sensor die. It's not. The complexities introduced by etching 3-D shapes and the need to process both the front and back of the silicon wafer make it difficult to produce an integrated sensor IC.

Only one totally integrated sensor is now commercially available—Motorola's MPX3100, which costs $62 (100). The MPX3100 is a 0- to 15-psi pressure sensor. Its chip-carrier package serves as the differential pressure-sensor element. The bottom side of the die is exposed to the environment, while the top side—comprising the die surface and the bond wires—is encapsulated in a silicone gel and further protected with a metal cover.

All the electronics are on the sensor die: the sensing diaphragm, the thin-film resistor network for calibration and temperature compensation, and the active linear circuitry for compensation and signal conditioning. Instead of the usual 100-mV output, the MPX3100 provides a 0.5



True wet/wet media compatibility *characterizes the 16PCD differential pressure sensor from Micro Switch. The design allows most types of media to be in direct contact with either side of the sensing chip. The cutaway sensor shows the suspended IC supported by tape-automated-bonding (Tab) bonds.*

Linearity definition varies among vendors

Be careful when you compare the linearity specifications of different manufacturers' products; the manufacturers have not agreed on a consistent method for determining this spec. As a result, the linearity of a pressure sensor manufactured by Motorola, for example, appears to be twice as large as the spec of a similar product from IC Sensors or Sensym.

Linearity is a measure of how well a sensor's voltage output behaves with respect to changes in temperature. On a graph, a linearity plot would ideally follow a straight line over the operating pressure range of the sensor. The specification defines the maximum amount that you can expect the sensor's output voltage to deviate from the ideal straight line at any point. Differences in the specification exist because manufacturers don't agree on where to position the ideal straight line relative to the actual output curve of the sensor.

Motorola uses the endpoints of the output curve to determine the ideal straight line. Sensym uses a "best straight line," which is positioned relative to the actual output curve so that the output curve has three points of equal maximum deviation from the line. In **Fig A,** these three points are the two endpoints and the 50% FS point on the performance curve. Micro Switch employs a third way of locating the ideal straight line, called the "least-squares fit," or the "best-fit straight line" (take care not to confuse the "best" with the "best-fit" straight line).

Although the output curve in the figure is slightly exaggerated, its shape does approximate the performance curves of most pressure sensors. Because of the resulting shape of these performance curves, a linearity spec calculated using the end-point straight line will be about twice as large as the spec calculated using the best straight line or the least-squares fit.

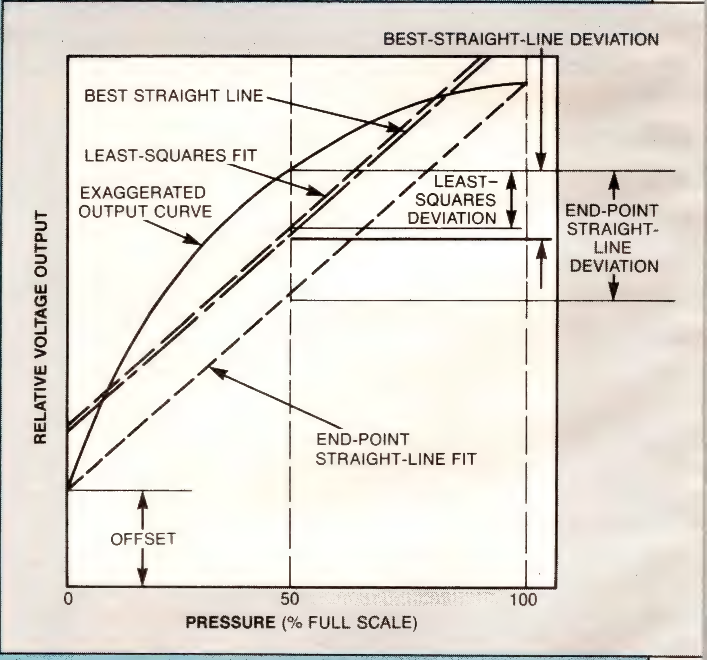


Fig A—A sensor's linearity specification defines the maximum deviation of a sensor's output *from an ideal straight line. But sensor manufacturers have not agreed on where to position the ideal straight line relative to the sensor's output; for example, the linearity for a sensor using the endpoint straight-line fit will appear to be about twice as poor as a similar spec using the best straight line or least-squares fit.*

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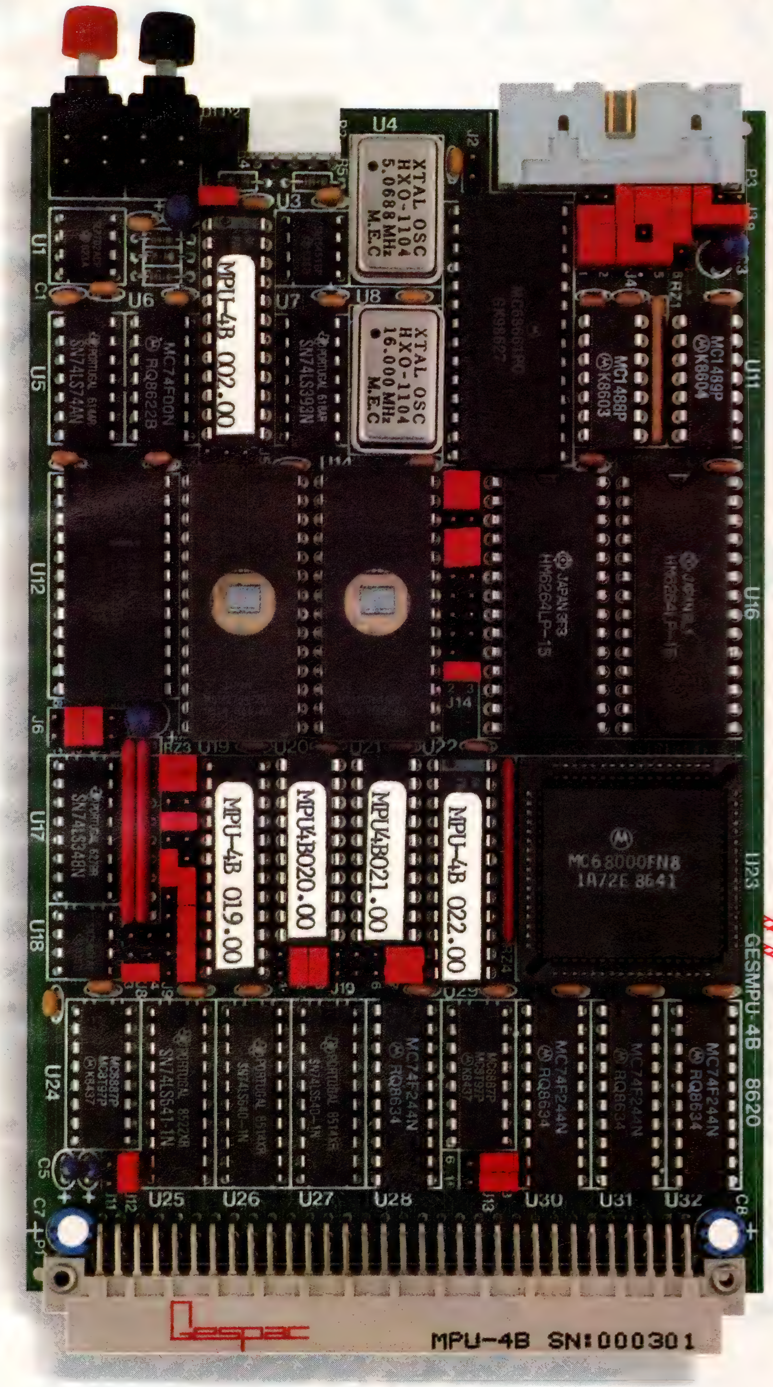

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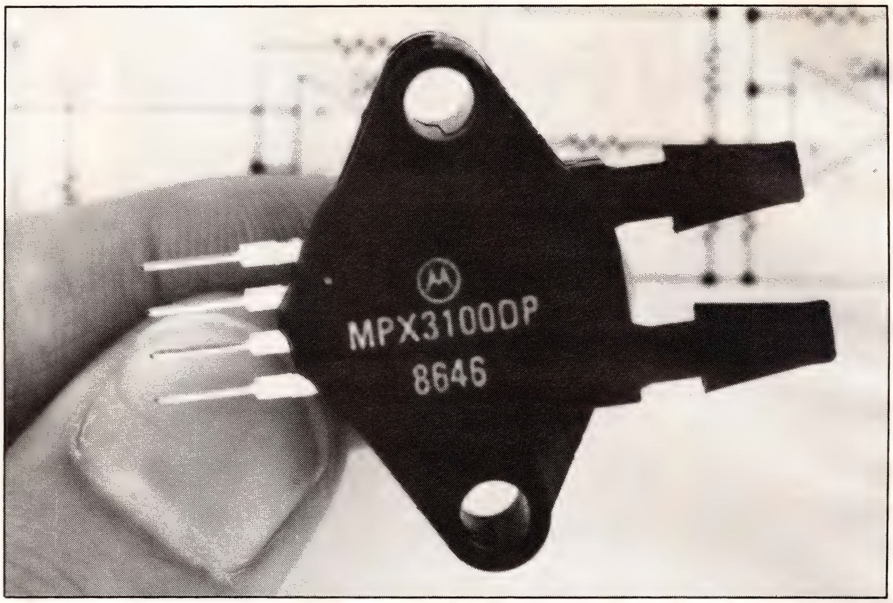

All the circuitry for temperature compensation, calibration, and signal conditioning is integrated on the sensor chip, thus allowing Motorola's MPX3100 to interface directly to any microcomputer with an onboard A/D converter.

to 3.0V output, which can be readily accepted by any microprocessor with an onboard A/D converter. The MPX3100's sensitivity specification is 170 mV/psi (25 mV/kPa), its span temperature coefficient is ±2% FS, and its offset-voltage temperature coefficient is ±50 mV. The linearity is ±0.2% FS.

Although the first integrated sensor was slow in coming, manufacturers are promising to introduce integrated products in 1987. For example, NovaSensor plans to introduce a family of pressure sensors that will have active on-chip signal conditioning. NovaSensor is also planning to supply a family of products with microprocessor-based signal conditioning. However, you probably will not see a pressure sensor integrated onto the same die with a microprocessor in 1987, although sensor manufacturers are making strides in that direction as well. **EDN**

Reference

1. Ormond, Tom, "Pressure sensors and transducers," *EDN*, May 1, 1986, pg 100.

Article Interest Quotient
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For more information . . .

For more information on the pressure sensors described in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

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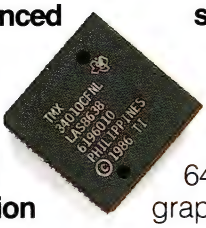

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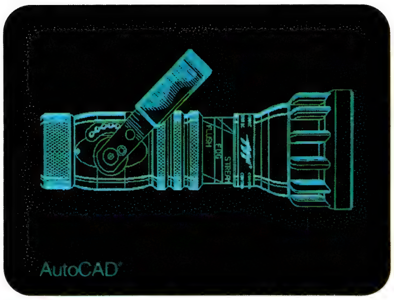

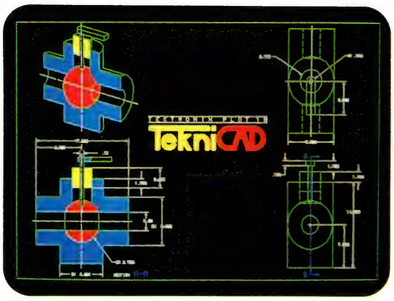

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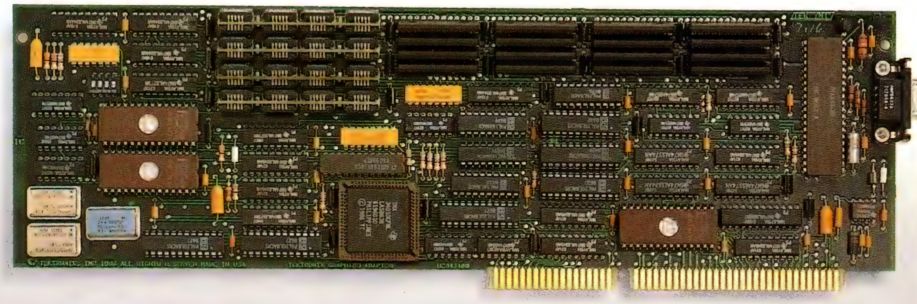
Release 2

Graphics System Processor for ultra-fast throughput of your design applications. Add to that Tek's PC-05 or PC-07 terminal emulation software, and you're ready for stand-alone computing or access to a world of mainframe graphics.

To bring those applications to life, you can connect a Tek color ink-jet printer. And start producing high-resolution, vibrant hardcopy output on either paper or transparencies.

Couple all that with Tektronix worldwide support and service, and your PC can gain the same productive advantages that host-based systems in scientific and engineering environments have had for close to two decades.

Tek's PC4100 graphics coprocessor board delivers serious graphics on a stand-alone basis. Built around the Texas Instruments Graphics System Processor(GSP),™ the graphics coprocessor board achieves a combination of sophisticated graphics and fast throughput your PC just couldn't deliver before. The GSP assumes the complete graphics processing workload, freeing your PC processor for other requirements.



New companion monitor brings together fine detail and maximum flexibility. You'll view your applications on Tek's new multiple-rate monitor. In true Tek tradition, it provides ideally balanced, 640x480 addressability and a 60 Hz non-interlaced refresh rate. So you can use advanced packages like AutoCAD,® Zenographic's Mirage™ and VersaCAD.®

Then, to move from GSP graphics to emulation of the IBM® Enhanced Graphics Adapter(EGA) mode, you simply soft-switch. And you're ready to run the popular PC packages you probably already use in CGA/EGA mode—standards like Lotus® 1-2-3,® Microsoft® WORD® and Microsoft® Windows,® to name just a few.

Last, but not least, Tek's PC4100 links you to a world of mainframe graphics. All you do is load Tek PC-05/PC-07.

Tek PC-05/PC-07 terminal emulation software gives you mainframe accessibility with the local processing power of your PC. Because Tek PC-05 and PC-07 terminal emulation software runs under MS-DOS® 2.0 and higher, you can run your mainframe-based

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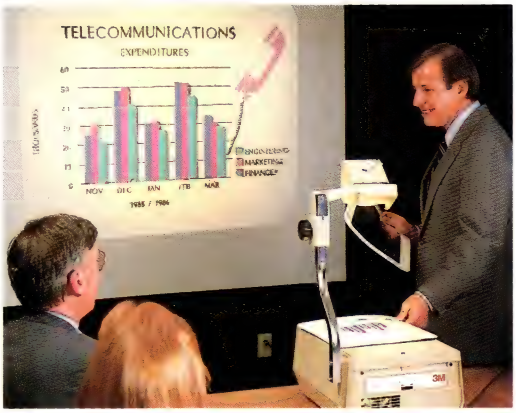
AND SETS YOU APART.



applications software on your PC as if it were a Tek 4105 or 4107 terminal.

Which means you can quickly access the power of Tek graphics—including 4107 segments, true zoom and pan, rubberbanding, definition of up to 64 viewports and more. You can use these highly productive features with a wide range of well-known designer software packages such as ISSCO's DISSPLA® and TELL-A-GRAF,® MCS's ANVIL-5000,™ SAS Institute Inc.'s SAS/GRAPH, Precision Visuals' DI-3000,® Swanson Analysis Systems' ANSYS® and McNeal-Schwendler's NASTRAN.

In addition, you can utilize software development tool sets like Tektronix PLOT 10® GKS, IGL, TCS and STI software as well as numerous driver support packages created for the 4105 and 4107.

Completing the picture: perfect color output with Tek's reliable ink-jet printers. At the push of a button, the Tek 4696 lets you produce exacting color reproductions of your on-screen display on either paper or transparencies.

Because of its 120 dots per inch addressability in both horizontal and vertical directions, you can achieve resolution of up to 1280 points x 960 points per "A" size image.

All the key tools for software development, right from the outset. The new Tektronix Graphics Interface™ (TGI) for the PC provides the basics of Tek graphics functionality to application programs running under MS-DOS. What's more, in-circuit emulator, C-compiler, assembler and linker are all available from Texas Instruments to help software developers write applications packages for the PC4100 graphics coprocessor board.

To enable sufficient workspace for custom interfaces or specific application programs, the PC4100 graphics coprocessor board comes standard with a full megabyte of program memory.

Put yourself on the sure path of Tek graphics evolution. Whether you choose Tek PC stand-alone graphics, Tek's high-resolution monitor, Tek terminal emulation or all three, you can be assured Tek will keep you current with the best and most productive graphics. Because like all our products, Tek Advanced PC Graphics features a smooth built-in pathway to higher-level graphics.

For more information about how Tek lets you stand alone and work together, contact your local Tek representative about Tek Advanced PC Graphics. Or call, 1-800-225-5434. In Oregon, 1-235-7202.

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Sophisticated mathematical software now runs on workstations and personal computers

Chris Terry, *Associate Editor*

Whatever your involvement with applied mathematics, you'll almost certainly be able to find a software package that can help solve your mathematical and engineeering problems and that runs on your workstation or personal computer.

If you're a software developer, you can link libraries of scientific subroutines to your application programs—you don't have to reinvent the wheel. If you're a hardware designer who needs quick mathematical solutions, you can use interactive packages that solve polynomial or differential equations right on the screen—they essentially act as computerized scratchpads. Some of these interactive packages can also generate and store the Fortran code that represents the operations you performed on the screen.

Libraries are maturing

Thirty years of software development have resulted in the implementation (in one or another of the high-level languages) of almost any algorithm you might wish to use. Further, in the quest for increased productivity, programmers have published many libraries of mathematical and scientific subroutines **(Table 1).**

There's nothing revolutionary about the development of these subroutine libraries; they are a natural outgrowth of the programming community's belief that knowledge should be shared. The libraries have certainly grown in scope and sophistication, however, keeping pace with new hardware developments and the needs of new fields of application (such as digital signal processing). Also, they have incorporated new algorithms that improve the speed and accuracy of various operations.

One noticeable trend is that these libraries, which have long been available for large mainframes, are now appearing in versions that run on workstations and personal computers. When you buy one of these libraries, you won't get the Fortran source code, but you will get a well-integrated library with good I/O control, error messages, and printer/plotter graphics. You'll also get telephone support in case you run into difficulties and, for an additional fee, update support.

Among the best-known of such packages is IMSL's collection. The Math/Library contains more than 400 linkable Fortran subprograms for accurate, reliable computation in such fields as linear systems, eigensystem analysis, integration and differentiation, differential equations, vector and matrix operations, and nonlinear equations. The Stat/Library gives you 350 subprograms for all types of statistical analysis.

The additional 170 subprograms of the Sfun/Library provide special functions such as gamma and related functions, Bessel and Kelvin functions, Weierstrass elliptic functions, and probability-distribution functions and inverses.

You'll find source code in books

If you want a library that comes complete with source code, your choices are somewhat restricted. Your best bet is to purchase a book that describes the algorithms in which you're interested and that provides concrete examples in Fortran, Pascal, or C. Several publishers offer such books as well as all of the code listings in machine-readable form.

At the low end of the line are such items as the 3-volume *Basic Scientific Subroutines*. These books describe complex variables, vector and matrix operations, series-approximation techniques, and many other mathematical functions. F Ruckdeschel has written the routines in Basic (naturally). Dynacomp sells the listings, in machine-readable form, in various formats (for Atari, Apple, and several CP/M machines as well as for the IBM PC). These formats are for Basic interpreters and may be slow. However, the vendor's Math Master Series comprises fast machine-language versions of the Basic Scientific Subroutines restricted to IBM PC, Apple, and TRS-80 machines.

At the top of the line is *Numerical Recipes: the Art of Scientific Computing,* from the Cambridge University Press. For each topic it considers, the book offers some general discussion, some analytical mathematics, a discussion of algorithmics, and actual implementations of the routines in the form of working Fortran and Pascal.

The book assumes that you are mathematically literate and know how to program a computer. According to the authors, "Our purpose is to open up a large number of computational black boxes to . . . scrutiny. We want to teach you to take apart these black boxes and put them together again, modifying them to suit your specific needs."

Topics include linear algebraic equations, integration and evaluation of functions, eigensystems, Fourier transform spectral methods, and ordinary and partial differential equations. The publisher can supply source code for all of the programs in the book in IBM PC format or several other formats. Users who work in technical labora-

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tories highly recommend this book and its associated programs.

Rapid progress in the development of inexpensive, medium-resolution graphics has resulted in the creation of a completely new type of mathematical aid—the interactive scratchpad (**Table 2**).

Microsoft's muMATH was the first attempt at a generalized mathematical utility. Originally released in 1979 for CP/M machines without any graphics, it's now been updated for the IBM PC.

The muMATH package acts as a command processor for routines written in muSIMP, a language specifically created to implement algebraic systems. From the keyboard, you can enter either a muMATH command or an expression,

TABLE 1—REPRESENTATIVE CALLABLE SUBROUTINE LIBRARIES

VENDOR	PRODUCT	LANGUAGE	SOURCE	FEATURES	PRICE	CIRCLE NO
BOEING COMPUTER SERVICES BOX 24346 SEATTLE, WA 98124 (206) 763-5000	BCSLIB	FORTRAN	NO	ELEMENTARY AND SPECIAL FUNCTIONS; POLYNOMIALS; ODEs AND PDEs; LINEAR ALGEBRA; STATISTICS; PROBABILITY.	FROM $8000 (VAX)	701
BORLAND INTERNATIONAL 4585 SCOTTS VALLEY DR SCOTTS VALLEY, CA 95066 (408) 438-8400	TURBO PASCAL NUMERICAL METHODS TOOLBOX	PASCAL	YES	ZEROS OF A FUNCTION; INTERPOLATION; DIFFERENTIATION; INTEGRATION; MATRIX INVERSION; EIGENVALUES; ODEs; FOURIER TRANSFORMS; LEAST SQUARES; GRAPHICS.	$99.95 (PC)	702
CAMBRIDGE UNIVERSITY PRESS 32 E 57TH ST NEW YORK, NY 10022 (212) 688-8885	NUMERICAL RECIPES	FORTRAN PASCAL	YES YES	LINEAR ALGEBRA; MATRICES; INTEGRATION; SPECIAL FUNCTIONS; NONLINEAR EQUATIONS; EIGENSYSTEMS; FOURIER TRANSFORMS; ODEs; PDEs; MODELING.	BOOK: $39.50 DISKS: $19.95 EA (2 PASCAL, 2 FORTRAN)	703
DYNACOMP 1064 GRAVEL RD WEBSTER, NY 14580 (800) 828-6722	BASIC SCIENTIFIC SUBROUTINES VOL 1	BASIC	YES	COMPLEX VARIABLES; VECTOR AND MATRIX OPERATIONS; RANDOM NUMBER GENERATORS; SERIES APPROXIMATIONS.	BOOK: $29.95 3 DISKS: $53.95	704
	BSS VOL II	BASIC	YES	LEAST SQUARES; SERIES, ITERATIVE, CORDIC APPROXIMATIONS; DIFFERENTIATION; INTEGRATION; ROOTS; OPTIMIZATION.	BOOK: $29.95 8 DISKS: $129.95	
	BSS VOL III	BASIC	YES	PROBABILITY DISTRIBUTIONS	BOOK AND DISK: $29.95	
IMAGE ACOUSTICS INC BOX 6 NORTH MARSHFIELD, MA 02059 (617) 834-6376	BESSEL	BASIC	NO	COMPILED HP-BASIC SUB AND FN ROUTINES FOR BESSEL, STRUVE, AND KELVIN FUNCTIONS AND LEGENDRE POLYNOMIALS.	$495 (H-P 200/300)	705
IMSL 2500 PARK WEST TOWER ONE 2500 CITYWEST BLVD HOUSTON, TX 77042 (713) 782-6060	MATH/LIBRARY	FORTRAN	NO	LINEAR SYSTEMS, EIGENSYSTEMS, ETC.	FROM $700 (PC)	706
	SFUN/LIBRARY	FORTRAN	NO	BESSEL, KELVIN, WEIERSTRASS, ETC.	FROM $420 (PC)	
	STAT/LIBRARY	FORTRAN	NO	REGRESSION, CORRELATION, ETC.	FROM $750 (PC)	
	COMPLETE LIBRARIES				FROM $900 (PC)	
MICROWAY BOX 79 KINGSTON, MA 02364 (617) 746-7341	87SFL	C AND ASSEMBLY	NO	ELEMENTARY AND SPECIAL FUNCTIONS; POLYNOMIALS; PROBABILITY; FOR 8087/80287 PC-FAMILY MACHINES. INTERFACES TO BASIC, FORTRAN, PASCAL, AND C PROGRAMS.	FIRST LANGUAGE, $250; EACH ADDITIONAL LANGUAGE, $100	707

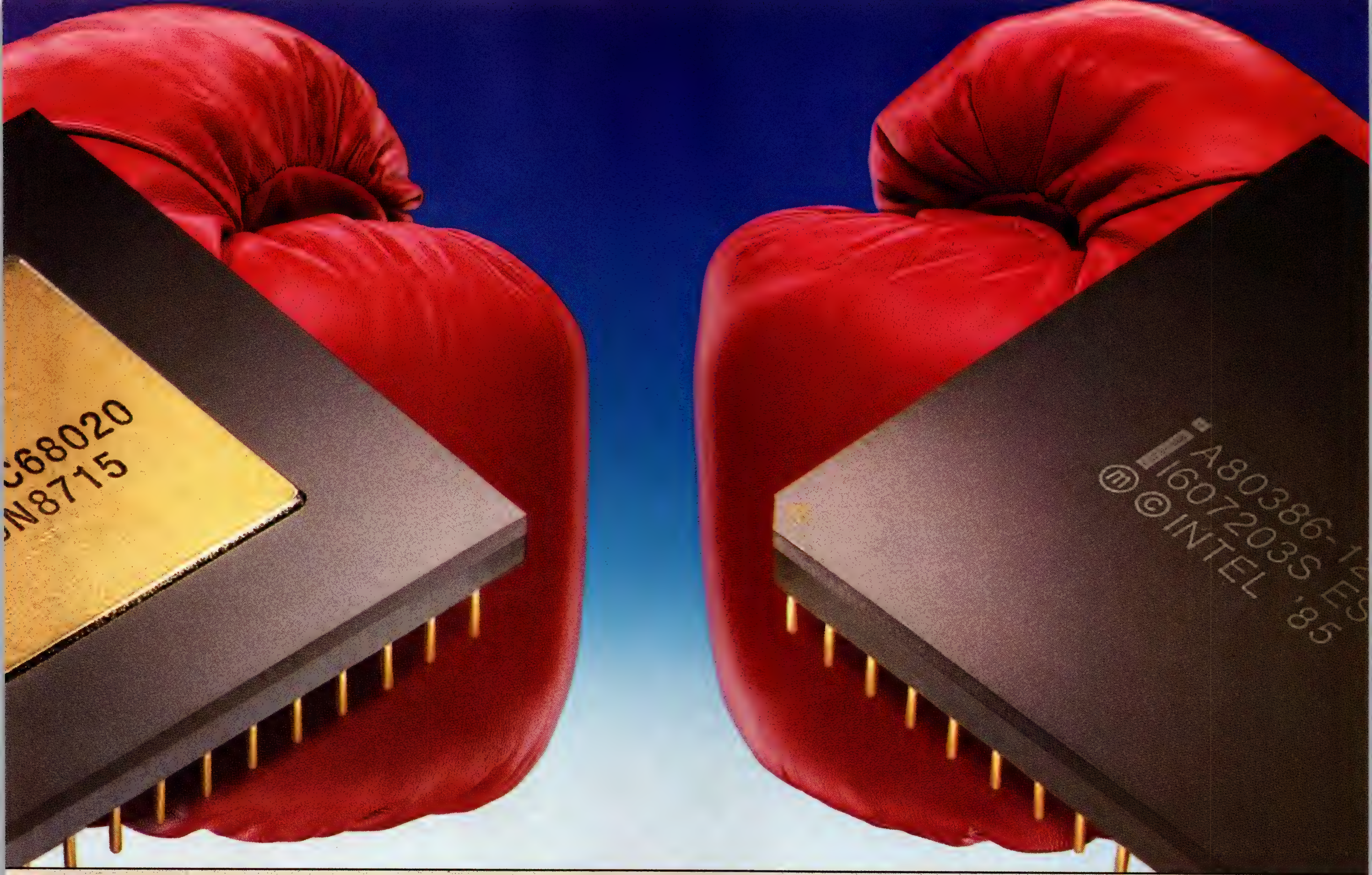
either of which the appropriate muSIMP module will evaluate. Several users have commented that muMATH is just fine for solving routine mathematical problems but that complex calculations are another matter. They're tricky to set up and may produce huge expressions for which there's no way of simplifying the terms. The utility is easy to learn, however.

Of all the interactive scratchpads for the IBM PC, the most impressive is MathCAD. The package has a main menu from which you select one of a series of submenus with a single keystroke. Within a submenu, you select a command by means of the cursor controls.

You can enter equations you want to solve either symbolically or with numeric parameter values. MathCAD makes extensive use of the PC's graphics capabilities, allowing you to specify symbols for differentiation, integration, and roots. These symbols appear on the screen well-formed and readable. A division operator causes the program to display the numerator and denomi-

TABLE 2—REPRESENTATIVE INTERACTIVE MATHEMATICAL AND SCIENTIFIC PACKAGES

VENDOR	PRODUCT	FEATURES	HOST	PRICE	CIRCLE NO
BORLAND INTERNATIONAL 4585 SCOTTS VALLEY DR SCOTTS VALLEY, CA 95066 (408) 438-8400	EUREKA: THE SOLVER	LINEAR AND NONLINEAR EQUATIONS; ROOTS OF POLYNOMIALS; TRIG AND CALCULUS FUNCTIONS; EDITOR; ON-SCREEN CALCULATOR; STATISTICAL AND FINANCIAL FUNCTIONS; USES 8087/80287 IF PRESENT.	IBM PC FAMILY	$99.95	708
HUNTER RESEARCH BOX G CUPERTINO, CA 95015 (408) 738-3066	HR-CONTROLS	GRAPHICS EDITOR FOR SYSTEM DEFINITION; STEADY-STATE, CONTINUOUS, OR DISCRETE FREQUENCY RESPONSE; ROOT LOCUS; MIMO FREQUENCY RESPONSE; KALMAN FILTER; GENERAL EIGENSOLVER.	IBM PC FAMILY	$650	709
MACMILLAN SOFTWARE CO 630 THIRD AVE NEW YORK, NY 10017 (800) 348-0033	ASYSTANT	DESK CALCULATOR; WAVEFORM GENERATOR; WAVEFORM PROCESSOR; CURVE FITTING; POLYNOMIALS; STATISTICS; DIFFERENTIAL EQUATIONS; GRAPHICS.	IBM PC FAMILY	$495	710
	ASYSTANT+	ADDS DATA-ACQUISITION AND DATA-OUTPUT FACILITIES.	IBM PC FAMILY	$895	
MATHSOFT INC 1 KENDALL SQUARE CAMBRIDGE, MA 02139 (800) 628-4223	MATHCAD	TEXT, FORMULAE, AND GRAPHICS ON SCREEN; DIFFERENTIATION; INTEGRATION; FFTs; CURVE FITTING; CUBIC SPLINES.	IBM PC FAMILY	$249	711
MATH WORKS INC 20 N MAIN ST, SUITE 250 SHERBORN, MA 01770 (617) 653-1415	PC-MATLAB	MATRIX MANIPULATION; POLYNOMIALS; ELEMENTARY MATH FUNCTIONS; DATA ANALYSIS; FFTs. REQUIRES 8087.	IBM PC FAMILY	$695	712
MICROSOFT CORP BOX 97017 REDMOND, WA 98073 (206) 882-8080	muMATH	ELEMENTARY ALGEBRA; ARRAY OPERATIONS; SIMULTANEOUS EQUATIONS; ODEs; DIFFERENTIATION; INTEGRATION; MATRIX OPERATIONS; VECTOR ALGEBRA; VECTOR CALCULUS.	IBM PC FAMILY	$300	713
SIGNAL TECHNOLOGY INC 5951 ENCINA RD GOLETA, CA 93117 (800) 235-5787	ILS-PC	DIGITAL SIGNAL PROCESSING; DIGITAL FILTERING; NUMERIC ANALYSIS; SPEECH PROCESSING; FREQUENCY ANALYSIS.	IBM PC FAMILY	$2495	714
	ILS STARTER	SUBSET OF ILS-PC.	IBM PC FAMILY	$495	
SYMBOLICS INC 11 CAMBRIDGE CTR CAMBRIDGE, MA 02142 (800) 622-7962	MACSYMA	FACTORING; EXPANSION; SIMPLIFICATION OF TERMS; SIMULTANEOUS EQUATIONS; ODEs; DIFFERENTIATION; INTEGRATION; CALCULUS MATRICES; TENSORS; NUMERIC ANALYSIS; FORTRAN-CODE GENERATION.	WORKSTATIONS	FROM $7500 (MICROVAX II)	715
SYSTEMS TECHNOLOGY INC 13766 S HAWTHORNE BLVD HAWTHORNE, CA 90250 (213) 679-2281	PROGRAM CC	FREQUENCY-DOMAIN AND TIME-DOMAIN ANALYSIS; MIMO SYSTEM ANALYSIS; STATE-SPACE ANALYSIS; KALMAN FILTER; BODE AND NYQUIST PLOTS; ROOT LOCUS.	IBM PC FAMILY	$3500	716



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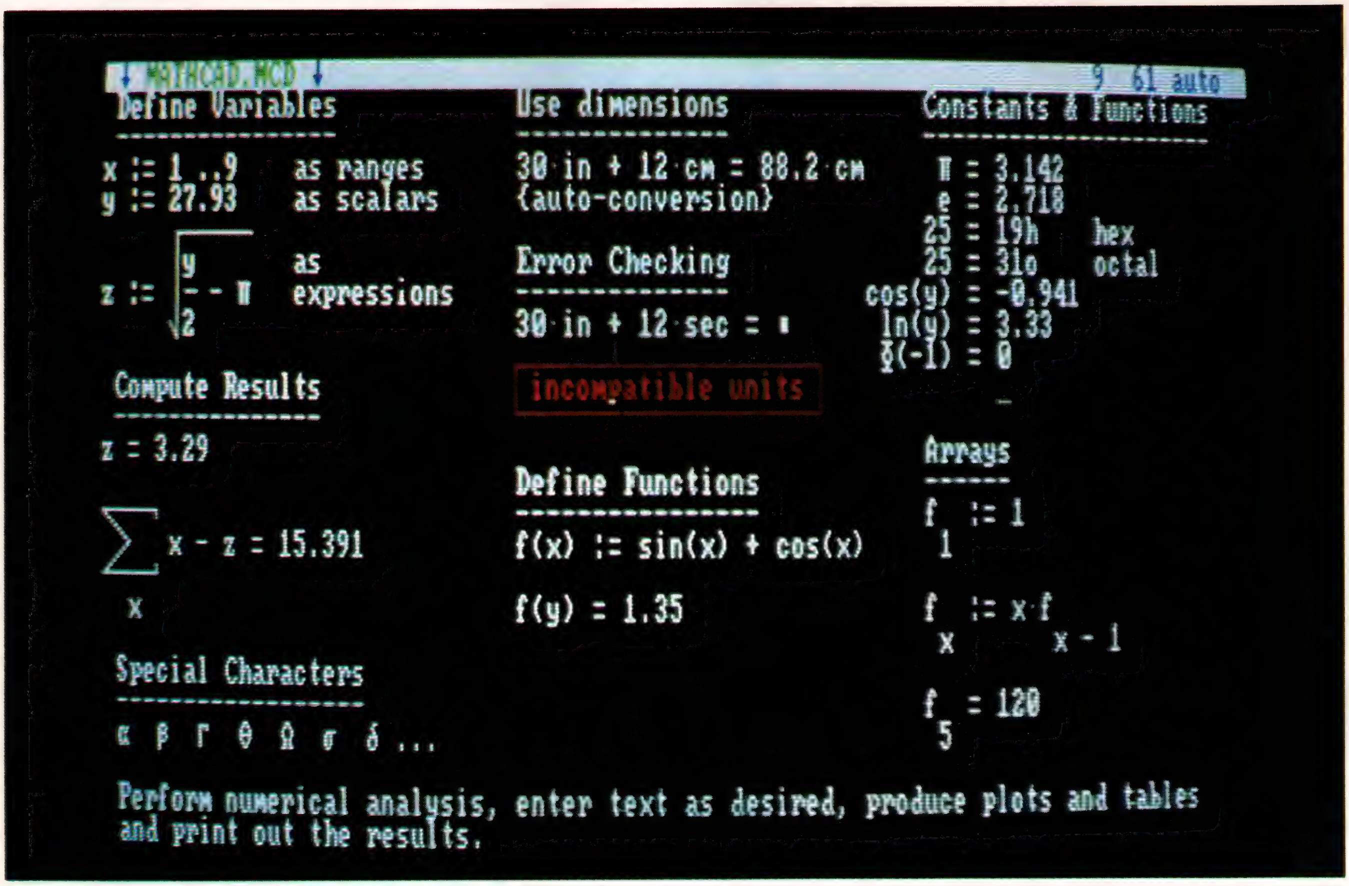

↓ MATHCAD.MCD ↓ 9 61 auto

Define Variables

x := 1 ..9 as ranges
y := 27.93 as scalars
z := $\sqrt{\frac{y}{2} - \pi}$ as expressions

Compute Results

z = 3.29

$\sum_{x} x - z = 15.391$

Special Characters

α β Γ θ Ω σ δ ...

Use dimensions

30·in + 12·cm = 88.2·cm
{auto-conversion}

Error Checking

30·in + 12·sec = ▮

incompatible units

Define Functions

f(x) := sin(x) + cos(x)

f(y) = 1.35

Constants & Functions

π = 3.142
e = 2.718
25 = 19h hex
25 = 31o octal
cos(y) = -0.941
ln(y) = 3.33
Φ(-1) = 0

Arrays

$f_1 := 1$

$f_x := x \cdot f_{x-1}$

$f_5 = 120$

Perform numerical analysis, enter text as desired, produce plots and tables and print out the results.

Fig 1—With the MathCAD interactive package, *which capitalizes on a personal computer's graphic capabilities, you can view differentiation, integration, and root symbols that are well-formed and clearly legible.*

nator above and below a proper division bar so that your equation is instantly intelligible. Superscripts and subscripts are properly sized and placed for maximum readability **(Fig 1).** Moreover, you can direct the screen content to a graphics printer, which will give you an exact copy of what you see on the screen.

In addition, you can use MathCAD with a wide variety of graphics adapters and monochrome or color monitors, including the EGA. The program automatically senses the presence of a Hercules monitor and makes the necessary adjustments to the display. The default color setting is white on a blue background, but you can change the colors if you wish.

The program provides a striking number of functions, including differentiation and integration by iterative approximation; you can adjust the tolerances for these and other iterative calculation routines. You can also calculate FFTs and their inverses for both discrete and complex values.

If, instead of a PC, you have a VAX, MicroVAX, or Sun (or comparable) workstation, you can buy an even more powerful mathematical tool. Symbolics' Macsyma is a stand-alone utility that combines symbolic and numeric analyses. This tool can factor, expand, and simplify algebraic expressions; solve systems of algebraic equations; and manipulate matrices and tensors. In the field of calculus, Macsyma can differentiate, integrate, take limits, solve ordinary differential equations, manipulate Taylor and Laurent series, and compute Fourier and Laplace transforms.

The command processor lets you work in either the interactive or batch mode. After trying different approaches in the interactive mode and after obtaining satisfactory results, you can store your procedures in a command file that you can later repeat in the batch mode.

For numeric analyses, you can compute with arbitrary precision, calling on the Macsyma library of numeric-analysis routines. If you wish, Macsyma will generate Fortran code that embodies your procedures and that you can call from an application program.

For real-time as well as off-line analysis, you have the option of data-acquisition packages. These packages place their emphasis on the acquisition of digital or analog signals through a hardware interface and on the subsequent analysis of the data. They provide mainly statistical and signal-processing functions, although they also have other useful features.

Macmillan Software Co's Asystant, for example, has a stack-based calculator that operates on arrays as well as on scalars. Reverse Polish notation is the default mode because

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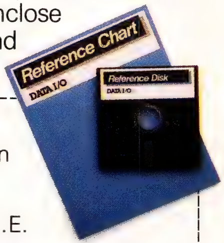

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DATA I/O

it is the most natural for stack-based calculators, but you can also use algebraic notation if you precede each command line with a backslash.

Asystant includes extensive array manipulation commands, a waveform generator, a waveform processor, curve-fitting routines, statistical routines, and routines for solving as many as five first-order differential equations. You actually have a choice of two versions: Asystant, which provides the calculator and analysis routines, and Asystant+, which has additional routines for data acquisition and is compatible with more than 20 data-acquisition plug-in boards.

Special programs, too

A number of the interactive math utilities in **Table 2** are of particular interest to control-system engineers. They provide mathematical functions useful for evaluating the performance and stability of closed-loop feedback systems.

They also incorporate graphical design aids that let you draw a block diagram on the screen, enter values for the major parameters of each block, and view the results in the form of Nyquist or Bode plots—or in any other form that you wish. Most of these specialized packages run primarily on workstations or superminicomputers, but several vendors supply packages for high-end machines in the IBM PC family.

Two such packages are HR-Controls from Hunter Research and Program CC from Systems Technology Inc. Both can solve control-system problems. You may select either classical control methods, such as forward- and feedback-loop transfer functions, or modern control methods, such as state-space models, time response, and Kalman gain functions.

Another specialized interactive program is Signal Technology Inc's ILS (Interactive Laboratory System). You'll find this package especially useful for digital signal processing, speech processing, image processing, and graphics displays. The company originally released ILS for workstations such as DEC's VAXStation and Masscomp's 5000 Series, but it's now available for the IBM PC family also.

The library has more than 80 Fortran routines, many of which facilitate linear prediction, frequency-domain operations, and digital filtering. A front-end processor provides both a menu mode and a command mode; these allow you to acquire data from external sources and process it with the built-in routines. You can obtain source code to help you in calling ILS routines from other programs or in integrating your routines into the package.

This article and the accompanying tables are by no means a complete listing of all the mathematical and scientific tools that are available. The aim has been to give you some idea of the trends in the field and to describe a few outstanding examples.

The days are long gone when first you had to write your own programs (or corral a reluctant programmer to write them for you) and then wait hours (or days) for the barely intelligible output of a batch program. Just as CAE tools are easing the work of the hardware designer, and CASE (computer-aided software engineering) tools are clarifying the design of complex software, new software tools are allowing mathematicians and scientists to work on the screen just as they did on paper—and in the process are removing sources of error and speeding up results. The calculator replaced the slide rule; we can only look forward to the time when interactive software packages replace the calculator as the day-to-day tool for all serious and complex calculations.

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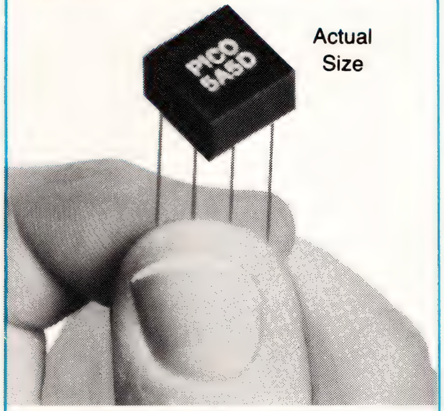

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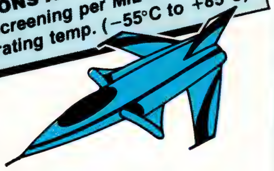

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	Z8 (Z8601/03/11/13-12R)	DIP40P	○
	SUPER-8 (Z8310-33)	DIP40/48P	○
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	8048 (8035/39/40/49/50AH)	DIP40P	○
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	MC68HC11	DIP48P	○
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	HD6301Y/6303Y, HD63701Y	SDIP64P	○
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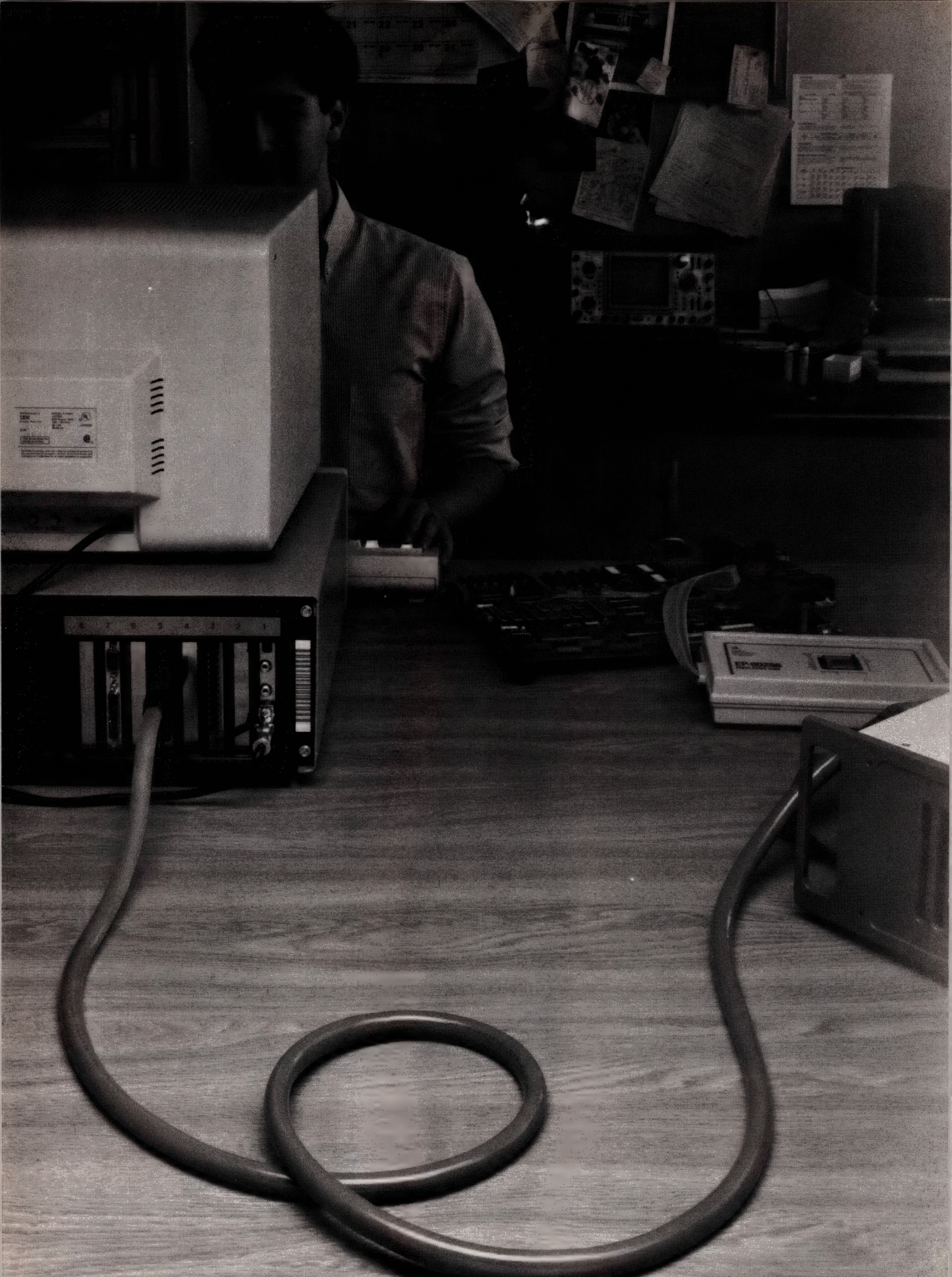

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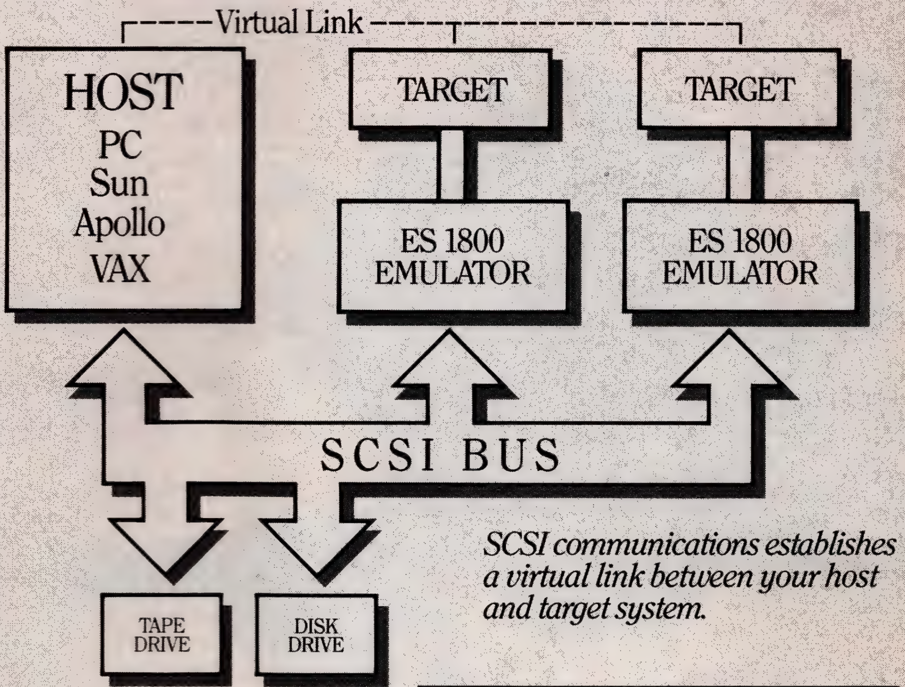

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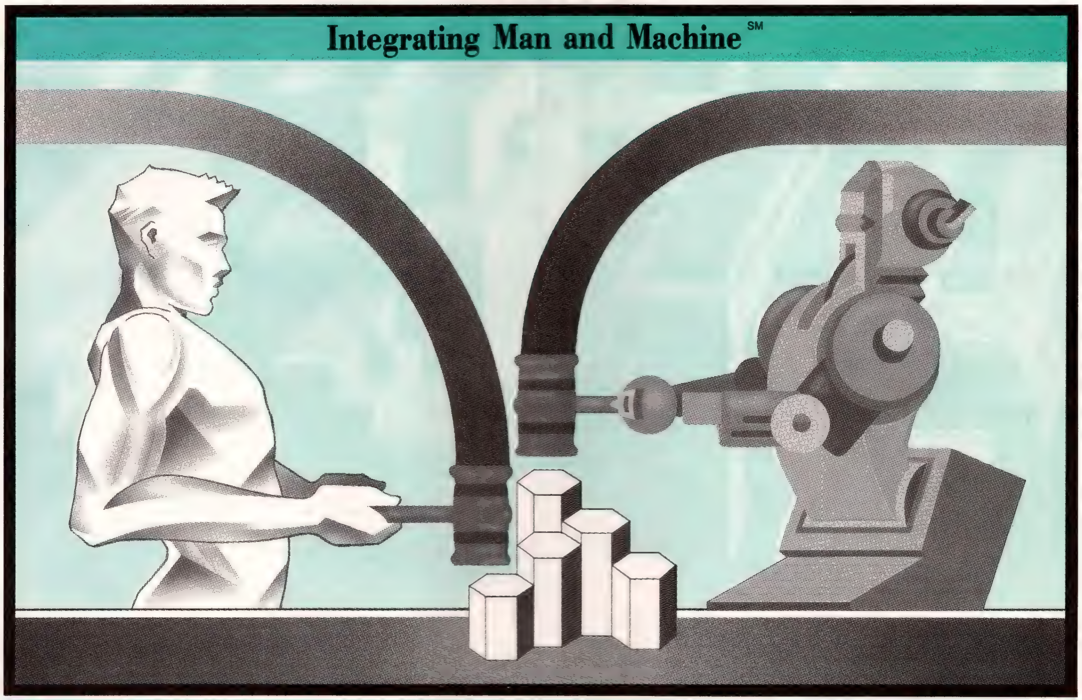

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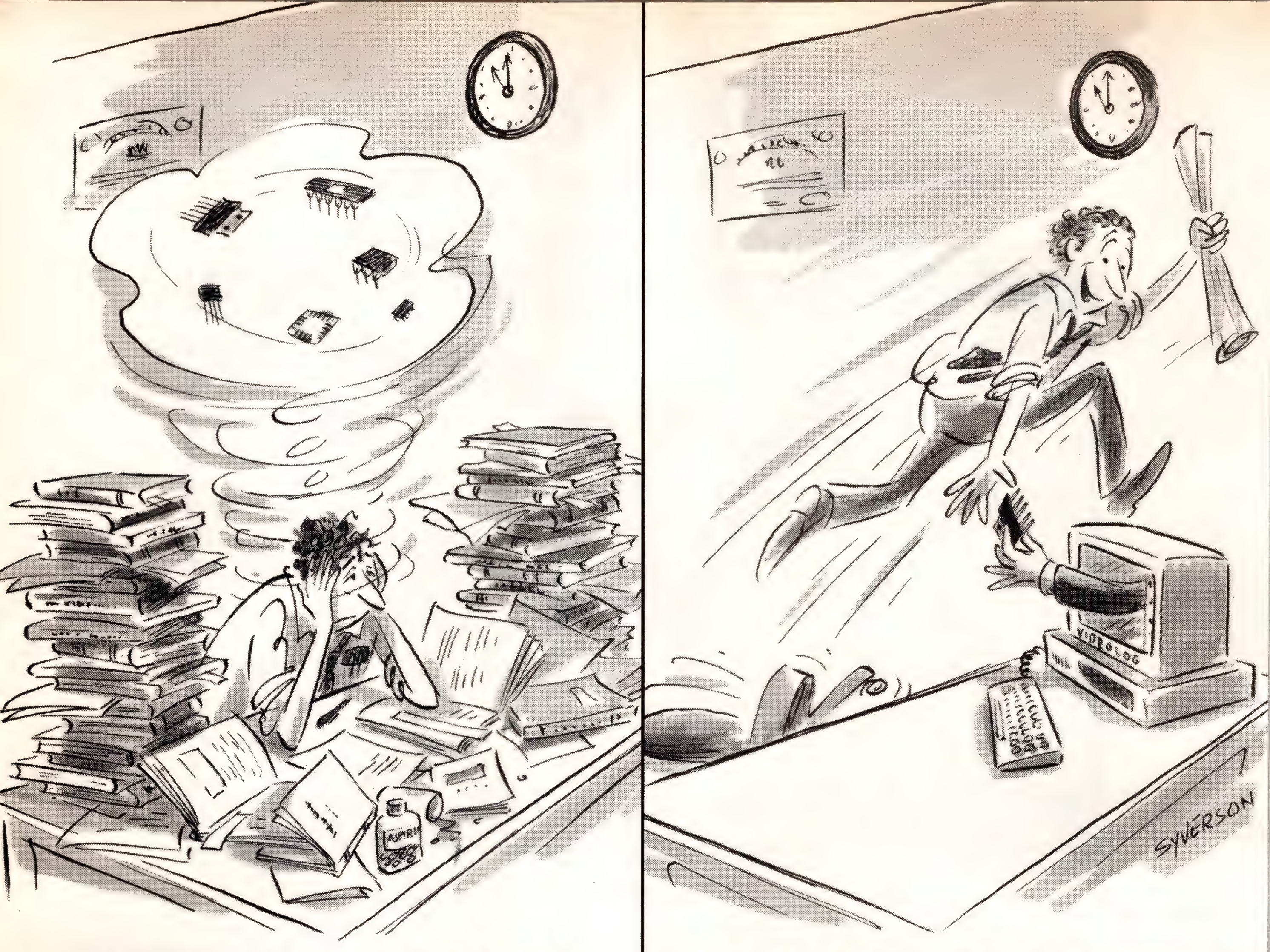

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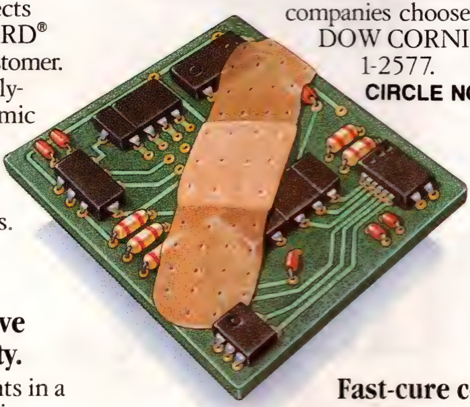

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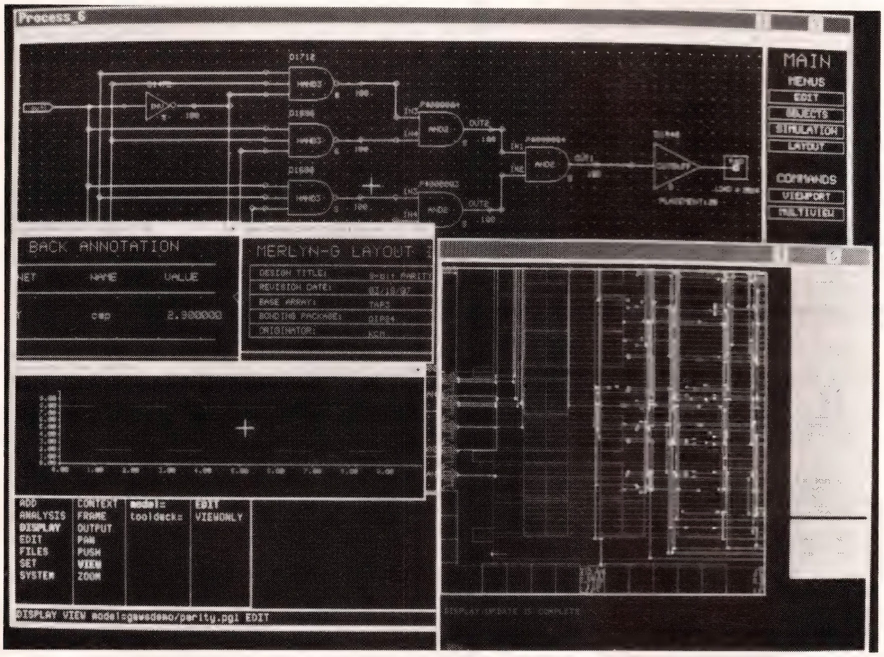
Integrated software lets logic designers design and lay out gate arrays in house

By using the Gate Array WorkSystem, you can design a gate array even if you don't have layout experience. The software lets the logic designer control all the phases of the gate-array design process, from schematic capture to physical layout. By combining foundry-endorsed layout algorithms with this vendor's TurnChip layout modules, the Gate Array WorkSystem lets you develop proprietary arrays in house. And because it maintains all design information on site, the software provides for maximum design security.

The WorkSystem eliminates the time-consuming design-revision cycles between the logic designer and the foundry. Instead of sending net lists to your chip foundry, you generate and send complete layout designs. Because the foundry performs only a final design check before fabricating your chip, the turn-around time is shorter and your design costs are lower.

The Gate Array WorkSystem automates and integrates schematic capture, logic simulation, functional and timing verification, and physical layout. The package uses a mouse-driven, menu-oriented interface but allows you to develop custom menus.

The schematic-capture module's multiwindow environment allows you to capture and simulate the logical representation of your design before performing verification and layout. You can use multiple windows to display the design and simulation results together, to display and compare different designs, or to display multiple views of the same design. A hierarchical database contains your design data and distributes it transparently among the WorkSystem's modules.



DISPLAY VIEW model=gawsdemo/parity.pgl EDIT

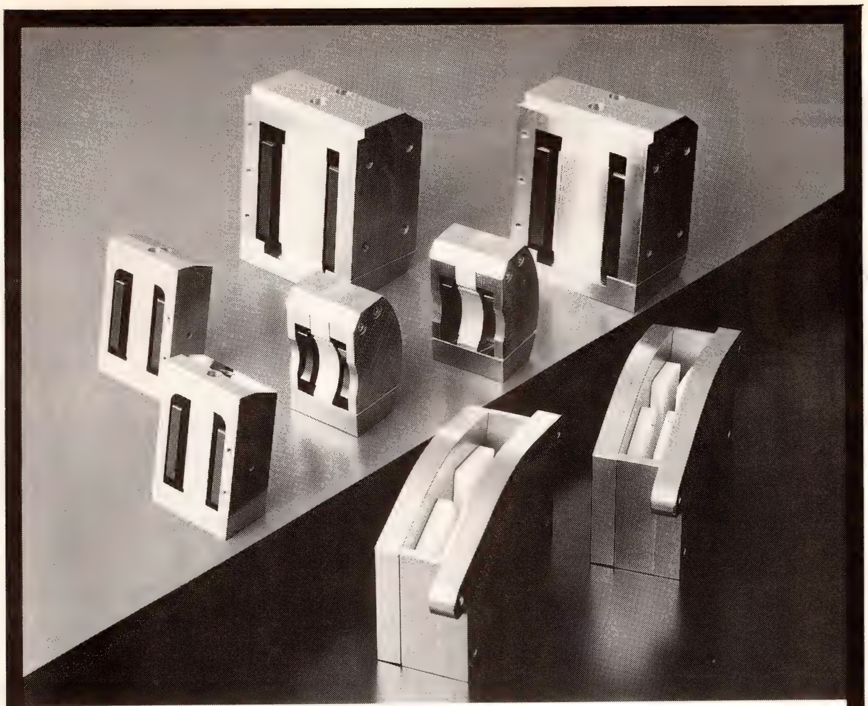
For creating and implementing circuit designs on gate arrays from specific foundries, *the Gate Array WorkSystem software integrates logic design, circuit simulation, and physical layout.*

To model logic circuits, you use the Hilo-3 logic-simulation module, which provides fault simulation and generates test patterns for diagnostic testing of your designs. You can also use this module to perform nominal and worst-case timing simulation and verification. The module's 5-state, 15-value logic-strength algorithm lets you model the technology-dependent behavior of MOS and ECL devices. This module handles the pull-up and pull-down characteristics at inputs and buses transparently and accurately.

The logic-simulation module integrates hierarchical, functional, and structural modeling. At any level of circuit description, you can freely mix structural and functional constructs to optimize the speed and accuracy of a logic simulation. The module's gate-level primitives and high-level functional constructs include circuit elements for pull-up devices and capacitive-charged decay. You can represent timing behavior as minimum, typical, or maximum rise and fall delays.

To specify the external environment for the circuit you're evaluating, you can choose graphical waveform or textual stimulus descriptions. You can then view the response from the circuit as either waveforms or textual listings. The system also monitors activity at internal circuit nodes; you can save these results for future analysis via a waveform-probing feature.

The WorkSystem also includes Merlyn-G, a physical-layout module that automatically performs such functions as device and macro placement, routing, and wire-path optimization. Merlyn-G generates a physical net list from your schematic and uses proprietary, quadratic



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The WorkSystem uses TurnChip software modules to provide knowledge-based control of the Merlyn-G layout system. These modules are rule-based expert systems that provide multiple routing strategies. Each TurnChip module contains specific layout information for a particular foundry's gate arrays, and each module has been approved by that foundry for use in the WorkSystem.

The TurnChip modules have a forward-annotation feature, which lets you specify layout parameters—such as device preplacement and net-priority specs—from your schematic. Back annotations update the schematic with wire-capacitance information and automatically generated pin and device names; these annotations appear directly on the schematic. Thus, you can control the layout process without entering the Merlyn-G module.

Suitable for developing 2000- to 6000-gate arrays, the Gate Array WorkSystem lets you specify design-performance attributes and design-dependent physical-layout constraints directly on the schematic. This feature lets you perform "what if" analyses to optimize your layout.

Standard versions of the Gate Array WorkSystem cost $70,000 and run on the DEC VAX II/GPX and Apollo 3000 workstations. TurnChip modules are currently available for three gate-array families: the 3900-gate C3900VH CMOS family from Fujitsu ($3900), the 3500-gate Q3500S bipolar family from Advanced Micro Circuits Corp ($3500), and the 2200-gate MPD-65022 CMOS family from NEC ($3500).—***J D Mosley***

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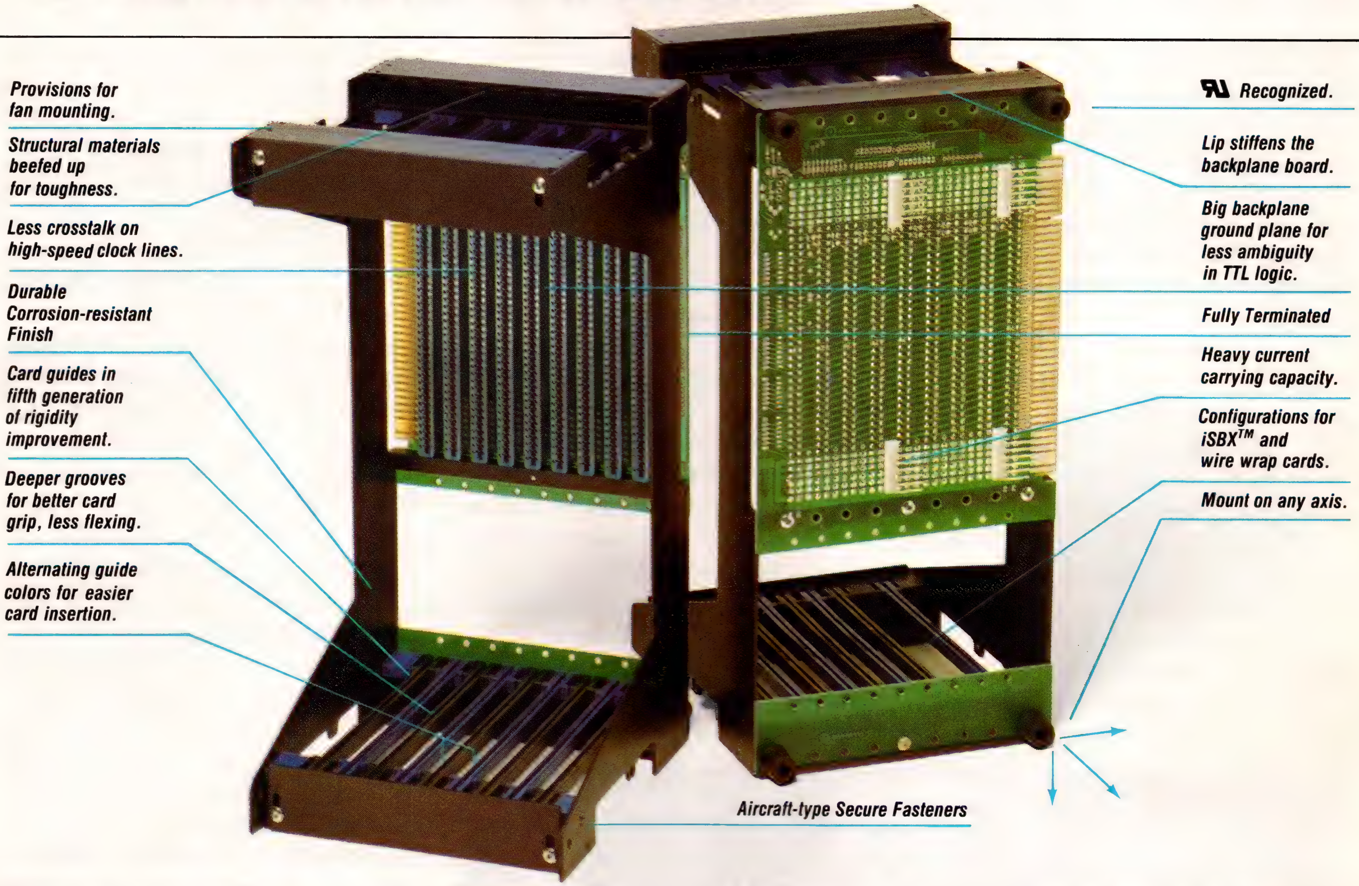
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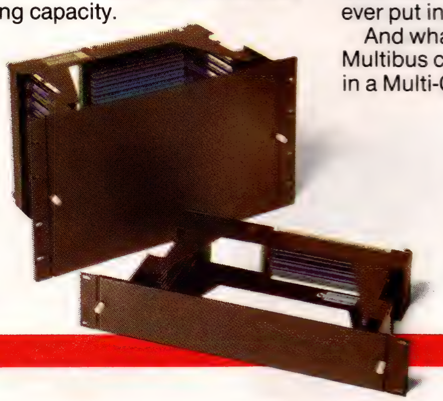

Multi-Cages through an evolutionary process have been made more and more rigid. So cards stay put better under shock and vibration conditions. Special aircraft-type fasteners never loosen their grip. And the brushed anodized aluminum finish has developed into one of the most corrosion resistant ever put into a card cage.

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CIRCLE NO 144

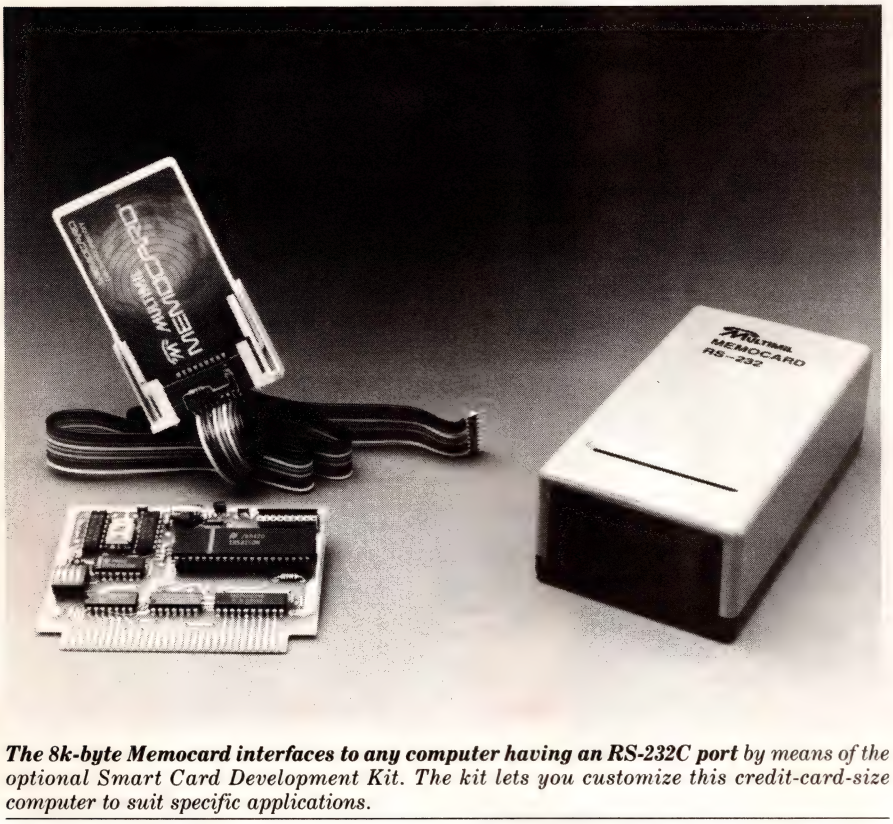
User-programmable smart card features 8k-byte EEPROM and 8-bit proprietary µP

The Memocard now has the largest EEPROM memory available for computer cards: 8k bytes. The card's proprietary 8-bit µP offers such features as random and sequential record searching and updating, password protection, and automatic assignment of record numbers.

A standard 8k-byte Memocard measures 2⅛×3⅜×1⁄16 in.—about the size of a credit card. However, you can order cards in any shape that suits your particular application. Each card is encapsulated in plastic for ruggedness. A 9-pin edge connector supplies the electrical contacts between the card's embedded electronics and an external terminal. To protect the card from physical counterfeiting, you can order customized designs that include magnetic stripes, photo IDs, holograms, bar codes, signature blocks, metal strips, watermarks, and color variations.

You can provide electronic security by several means. You can have a single- or dual-key data-encryption algorithm manufactured into the µP's ROM to secure all data passing between the EEPROM and the µP or between the µP and the terminal. You can also let individual users define the maximum allowable number of incorrect access attempts, and you can assign an authorization level to each card. A nonaccessible ID and a user-modifiable, 32-character (alphanumeric) personal identification code offer added security.

The card's EEPROM technology supplies nonvolatile data storage. The data stored in EEPROM can't be read by electronic scopes or other scanning devices. The card requires power from a standard 5V source only during read and write functions. The Memocard also has electronic longevity: You can rewrite each of the EEPROM's memory locations 10,000 times without degradation of the data.



The 8k-byte Memocard interfaces to any computer having an RS-232C port *by means of the optional Smart Card Development Kit. The kit lets you customize this credit-card-size computer to suit specific applications.*

An optional IBM PC-compatible Smart Card Development Kit is available to help you program the Memocard. The kit includes a Memocard, software, sample programs, instructions, documentation, and an RS-232C-compatible interface unit or a PC expansion board with a half-height bezel. The expansion board provides a direct or memory-mapped I/O link between the Memocard and the IBM PC bus, thus maximizing data transfer at 9600 bps and eliminating RS-232C protocol conventions. The RS-232C interface unit provides a 4800-bps read/write link between the Memocard and virtually any computer with an RS-232C port. If you don't want to program the Memocard yourself, you can have the manufacturer do it for you.

Because of the card's memory capacity and onboard µP, applications for the product include computer-network security, process-control auditing, database management, and field-service control. The 8k-byte Memocard sells for $62.55; a 2k-byte version sells for $35.55 (10,000). The Smart Card Development Kit costs $489.—***J D Mosley***

Multimil Inc, 670 International Parkway, Suite 190, Richardson, TX 75081. Phone (214) 644-7724. TLX 286258.

Circle No 731

Assemblers/Simulators/Compilers

Macro Assemblers/ Cross Assemblers
for Series 3.0

Series 3 requires at least 256k of memory to run under MSDOS & CP/M86 and 54k TPA of memory to run CP/M80. Series 3 products have: Full Listing Control, Conditional Assembly & Built in Cross Reference. There is Unlimited Program Size, Number of Symbols and Macros. The Linkers output: Intel Hex, Extended Intel Hex, Tektronix Hex, and Motorola S19, S28, S37 formats.

Macro Assemblers/ Cross Assemblers
for Series 4.0

Series 4 requires 512k of memory to run. These products have all the features of Series 3 plus: 32 Character Labels, Library and User Defined Sections. There is one Linker on Series 4 which outputs all the same formats as Series 3. Series 4 runs under MSDOS, UNIX, VMS and ULTRIX.

Simulator-Debuggers

The Simulator-Debuggers run with 256k of memory. The Simulator has 16 Breakpoints with optional Counter Field. The Symbol Table is limited only by the amount of memory. Buffers of 256 bytes may be opened for I/O ports. The Simulators are available for MSDOS, UNIX, VMS and ULTRIX.

C Compilers

The C Compilers support in-line assembly language and ROMable code, and includes the following: Macro Processor, full Floating Point support, complete Assembler, Linker, and Libraries.

	Macro Assemblers Cross Assemblers			**Simulator-Debuggers**		**C Compilers**	
	Series 3	**Series 4**					
Software Product	**CP/M 80 CP/M 86 MSDOS**	**MSDOS AT&T UNIX**	**VMS Zeus ULTRIX**	**MSDOS AT&T UNIX**	**VMS Zeus ULTRIX**	**MSDOS AT&T UNIX**	**VMS Zeus ULTRIX**
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6301	199.50	199.50	995.00	149.50	499.50		
64180	199.50	199.50	995.00			500.00	2000.00
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6502	199.50	199.50	995.00				
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65c816		299.50	1250.00				
6800,2,8	199.50	199.50	995.00	149.50	499.50		
6801,3	199.50	199.50	995.00	149.50	499.50		
6804	199.50	199.50	995.00				
6805	199.50	199.50	995.00				
6809	199.50	199.50	995.00	149.50	499.50		
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8400/c00	199.50	199.50	995.00				
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8044/51	199.50	199.50	995.00	149.50	499.50		
80515		199.50	995.00				
8080	199.50	199.50	995.00	149.50	499.50		
8085	199.50	199.50	995.00	149.50	499.50		
8086/88	99.50	99.50	1250.00				
8096	199.50	199.50	1250.00				
80186/286	199.50	199.50	1250.00				
83c351		199.50	995.00				
8748	199.50	199.50	995.00	149.50	499.50		
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CIRCLE NO 145

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Low-power CMOS EEPROMs operate at 35 nsec while consuming 350 mW

The 38C16 and 38C32 2k×8-bit and 4k×8-bit high-speed CMOS EEPROMs operate from one 5V supply. The chips' maximum address-access time is 35 nsec, and their chip-enable and output-enable times are both 20 nsec.

To write data to one of these devices, you use the EEPROM as you would any RAM. The internal address and data latches latch the inputs during the high-speed portion of the process. The internal circuitry of the 38C16/32 keeps the address and data stable for the required 5 msec.

By reading the output, the processor can poll the EEPROM to see if the writing process is complete. As the data is written to storage, it's also complemented and made available to the output, so any data read from the EEPROM before the end of the write cycle is not true data. The data read from the EEPROM after the write cycle finishes is the true data.

The EEPROM family also includes the 36C16 and 36C32, which can replace bipolar PROMs. These devices also have a 35-nsec maximum address-access time, but they don't have the on-chip latches for use during writing.

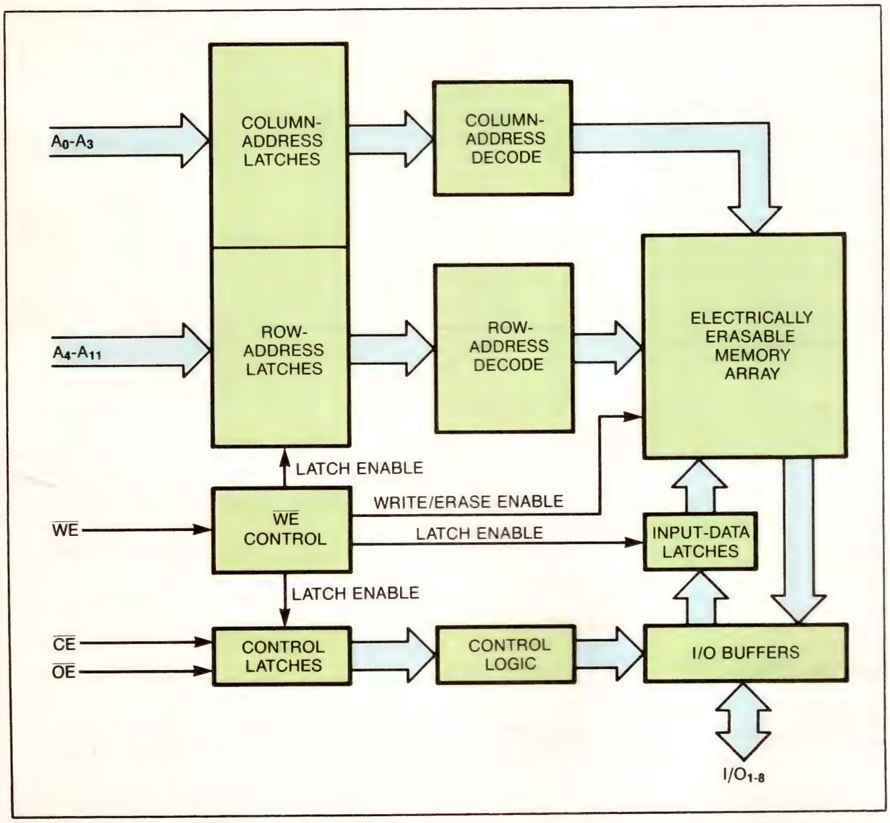
The endurance specification for the 38C16/32 and 36C16/32 states that a maximum of 1% of the devices will fail before reaching 10,000 cycles.

EEPROM endurance is usually specified according to the number of erase/write sequences (usually 10,000 cycles) they can endure. By itself, however, such a spec is meaningless. You also need to know the maximum percentage of devices that will have failed before reaching the specified number of cycles. Many data sheets don't make this percentage readily apparent. When you compare the endurance specs for EEPROMs, therefore, you'll need to ask each manufacturer exactly what its spec means, so that you can compare the products on equal terms.

Samples of all four of the devices will be available in June, and OEM quantities will be available by the fourth quarter of 1987. The 38C16 and 38C32 cost $27 and $38, respectively; the 36C16 and 36C32 cost $18 and $30 (100).—***David Shear***

Seeq Technology Inc, 1849 Fortune Dr, San Jose, CA 95131. Phone (408) 432-9550. TWX 910-338-2313.

Circle No 730



Having a maximum access time of 35 nsec, *the 38C16 and 38C32 CMOS EEPROMs include the latches and timing circuitry needed for writing to the memory array.*

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CIRCLE NO 146

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4387

CIRCLE NO 28

3½-in. Winchester has 170M-bytes unformatted capacity

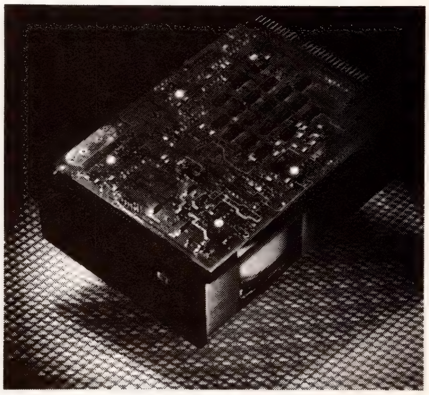
The LXT-170 stores 170M bytes of unformatted data in a standard 3½-in. package and offers you a choice of a SCSI- or ESDI-interface version. The drive's head/disk assembly contains five platters of thin-film plated media and a rotary straight-arm actuator powered by a voice-coil motor. An in-hub spindle motor leaves room for the five platters.

To achieve the 170M-byte storage capacity, nine of the disk surfaces store data, and one contains positioning information for the dedicated servo system. The actuator/motor/servo combination results in an average seek time of less than 20 msec and a maximum seek time under 40 msec. Decoding SCSI commands adds 850 μsec to the drive's seek time.

Like a 5¼-in. drive, the LXT-170 specs a rotational latency of 8.3 msec. Its read channel and servo controller store data at 1360 tracks/in. and 15,888 bits/in. MTBF exceeds 30,000 hours; MTTR is 30 minutes. The Winchester dissipates less than 20W and measures 1.625×9×5.75 in.

Both the SCSI and ESDI versions attain 10M-bps data rates in the read channel and use RLL 2,7 encoding schemes. The read-channel and head/media combination yields a soft-error rate of less than 10 in 10^{11} bits and a hard-error rate of less than 10 in 10^{13} bits. The SCSI version also includes ECC circuitry and a cylindrical-zoning defect-management scheme.

The SCSI drive supports a 1.5M-byte/sec asynchronous data rate at the I/O bus, and it supports SCSI disconnect/reconnect features, all mandatory CCS (Common Command Set) commands, and optional commands such as mode sense and mode select.



***Embedded-SCSI and ESDI versions** of the LXT-170 Winchester store 170M bytes of unformatted data and fit into the 3½-in. form factor. Average seek operations take less than 20 msec.*

The company plans to begin shipments of the ESDI version around midyear and intends to start shipping embedded-SCSI drives by the end of the third quarter. Initial pricing of either version will be under $1100 (1000); you can expect prices to fall below $1000 in 1988.

—Maury Wright

Maxtor Corp, 150 River Oaks Parkway, San Jose, CA, 95134. Phone (408) 942-1700. TLX 171074.

Circle No 732

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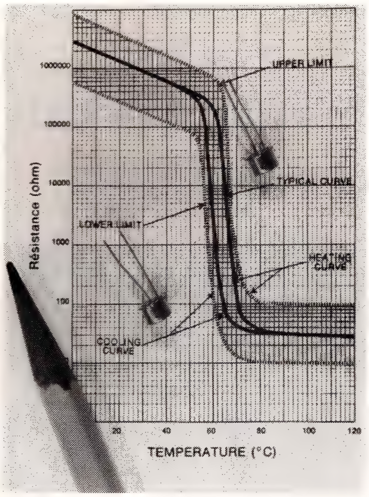

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CIRCLE NO 29

PRODUCT UPDATE

Sub-$550 40M-byte drive meets 3½-in. standard

Selling for less than $550 (1000), *the LT4000 Spartan is a 40M-byte Winchester that fulfills the new small computer systems' need for commodity drives.*

The LT4000 Spartan features a formatted capacity of 45M bytes and targets the emerging generation of personal computers (and many µCs in general) that will include 40M-byte Winchester drives. In addition, the drive costs less than $550 (1000-piece price), and you can expect the price to drop substantially within a year. Thanks to its price and capacity, the drive meets the criteria for the new class of commodity drives.

For 3½-in. data-storage peripherals, half-height products are standard. The Spartan drive fits this format and includes an embedded SCSI (Small Computer System Interface) controller. The controller implements all mandatory commands of the CCS (Common Command Set) as well as many of the optional commands.

The drive transfers data at 1.2M bytes/sec asynchronously to the SCSI bus. The controller provides an 8k-byte block of memory for buffering the data, and it supports the SCSI disconnect/reconnect feature. The read channel operates at a 10M-bps data rate.

The Spartan's head/disk assembly consists of two platters with four data surfaces and read/write heads. Although the drive employs a stepper motor to drive the actuator, it can perform average seek operations in less than 35 msec. Worst-case seek operations take less than 80 msec. Operating from either a 5 or 12V supply, the Spartan dissipates 15W.

Error rates for this Winchester disk drive meet the industry standard: 1 in 10E10 bits for soft errors, and 1 in 10E12 for hard errors. ECC circuitry can detect 32 error bits in any sector and correct an 8-bit error burst. The drive's specified MTBF is 28,000 hours; the manufacturer estimates its MTTR as 20 minutes.

—Maury Wright

LaPine Technology Corp, 182 Topaz St, Milpitas, CA 95035. Phone (408) 262-7077.

Circle No 734

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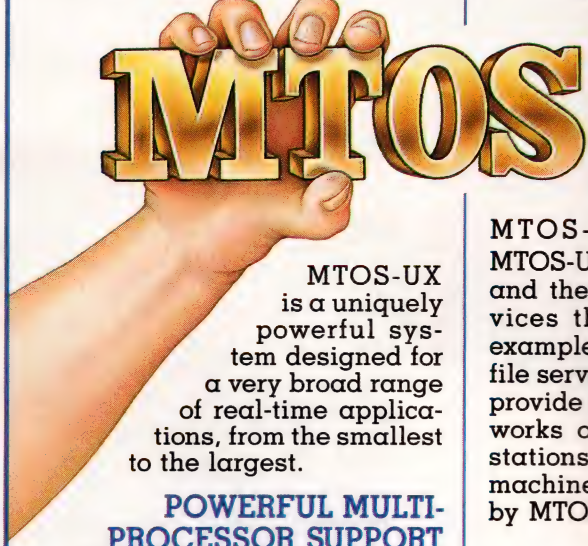

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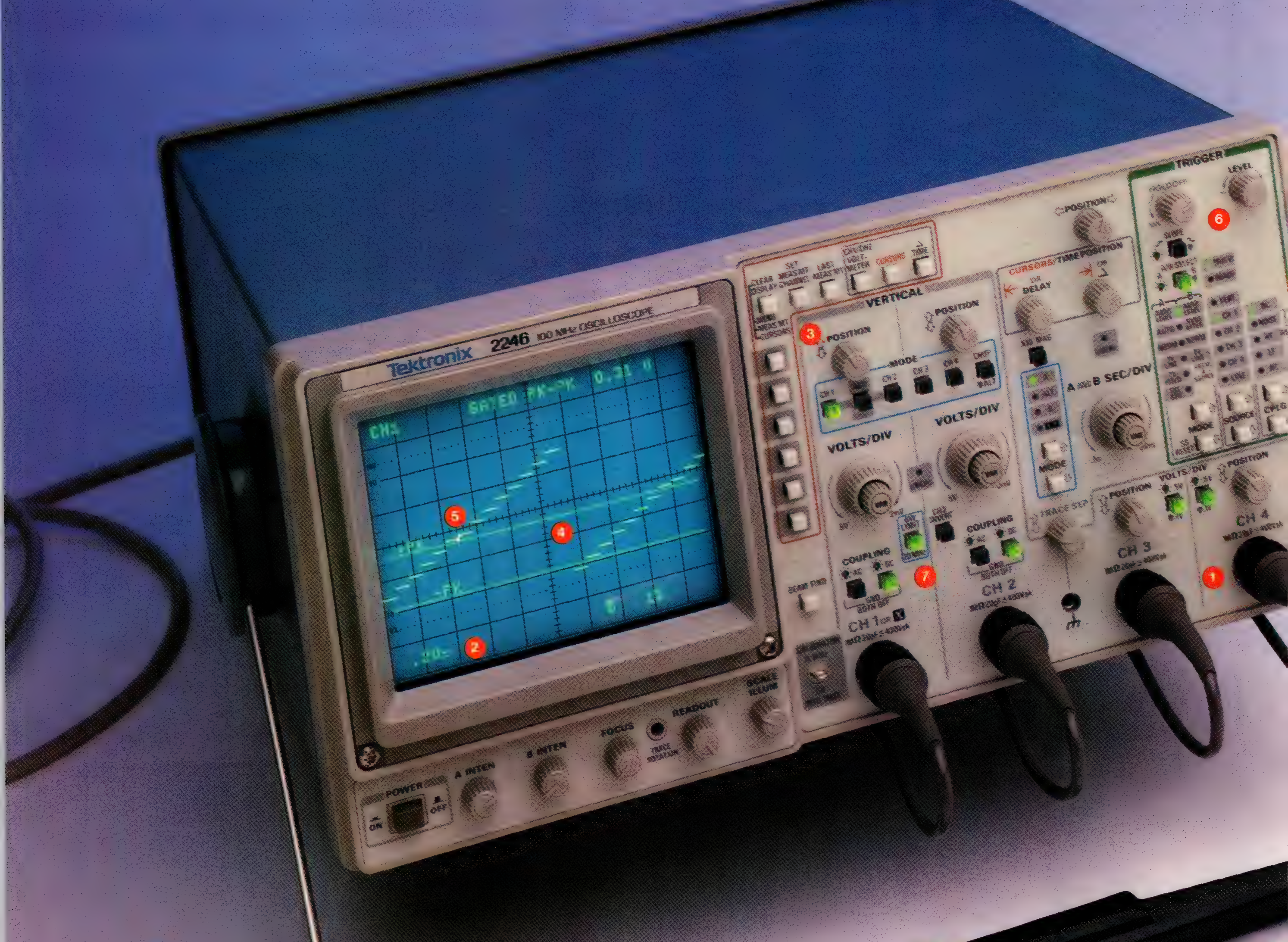
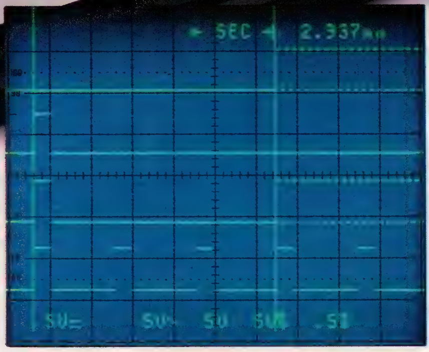
CIRCLE NO 148

New GPS Series: with SmartCursors™



① Four channels with 100 MHz bandwidth. ② CRT readout of scale factors and measurement results. ③ Menu functions controlled by the top row of push buttons. ④ SmartCursors™ track ± peak or peak-to-peak voltage measurements. ⑤ Gated voltage mode makes it possible to itensify a portion of a waveform and make voltage measurements on that segment only. ⑥ Versatile triggering lets you trigger the main or delayed sweep on any of the four channels. ⑦ Backlit control buttons verify that a function is active.



The 2246 provides direct time readout information when seconds is selected in cursor mode. You also have 1/seconds in Hz and phase capability.

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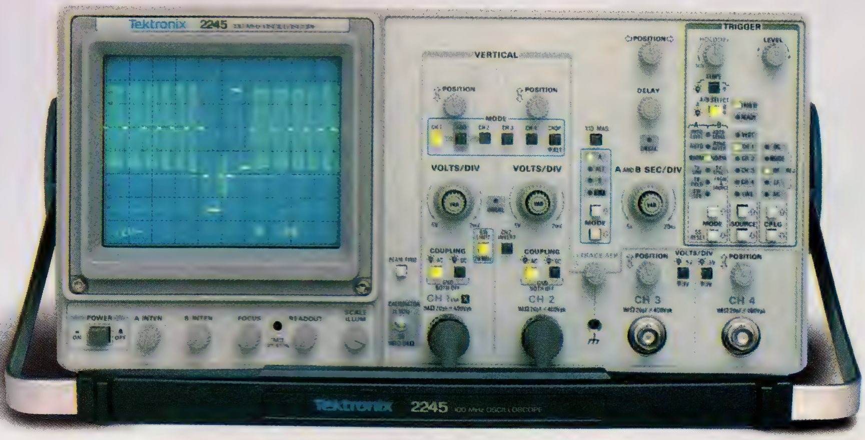
Tek sets the pace and push-button ease.

Work faster, smarter, with two new general purpose scopes from Tek. The four-channel, 100 MHz 2246 and 2245 set the new, fast pace for measurements made daily at the bench or in the field. They're easy to use and afford, by design. And backed by Tek's three-year warranty that includes the CRT.

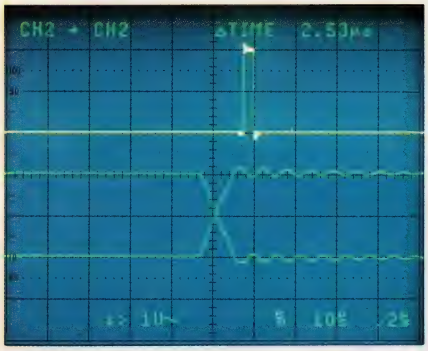
On top: the 2246 with exclusive integrated push-button measurements. Your measurements are accessed through easy, pop-up menus and implemented at the touch of a button. Measure ± peak volts, peak-to-peak, dc volts and gated volts with new hands-off convenience and on-screen readout of values.

SmartCursors™ track voltmeter measurements in the 2246 and visually indicate where ground and trigger levels are located. Or use cursors in the manual mode for immediate, effortless measurement of waveform parameters like voltage, time, frequency, and phase.

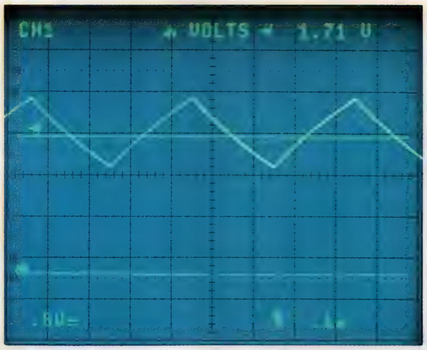
Both scopes build on performance you haven't seen at the bandwidth or prices. Lab grade features include sweep speeds to 2 ns/div. Vertical sensitivity of 2 mV/div at full bandwidth for low-level signal capture. Plus trigger sensitivity to 0.25 div at 50 MHz, to 0.5 div at 150 MHz.



Features	2246	2245
Bandwidth	100 MHz	100 MHz
No. of Channels	4	4
Scale Factor Readout	Yes	Yes
SmartCursors™	Yes	No
Volts Cursors	Yes	No
Time Cursors	Yes	No
Voltmeter	Yes	No
Vertical Sensitivity	2 mV/div	2 mV/div
Max. Sweep Speed	2 ns/div	2 ns/div
Accuracy: Vert/Hor	2%/2%	2%/2%
Trigger Modes	Auto Level, Auto, Norm, TV Field, TV Line, Single Sweep	
Trigger Level Readout	Yes	No
Weight	16.5 lb/7.5 kg	16.5 lb/7.5 kg
Warranty	3-year on parts and labor including the CRT	
Price	$2400	$1875



Conventional ΔTime measurement is also available from the menu in the 2246 for increased timing accuracy. Shown above: a ΔTime measurement of pulse width.



The 2246 also makes it possible to measure either ΔVolts or absolute volts from ground.

Best of all, high performance comes with unmatched convenience. You can see it and feel it—in the responsive controls and simple front-panel design, in extensive on-screen scale factor readouts, and in simplified trigger operation that includes Tek's Auto Level mode for automatic triggering on any signal. Start to finish, the GPS Series saves steps and simplifies tasks.

Get out in front! Call toll-free today to order, to get more details or a videotape demonstration.
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In Oregon, call collect
1-627-9000

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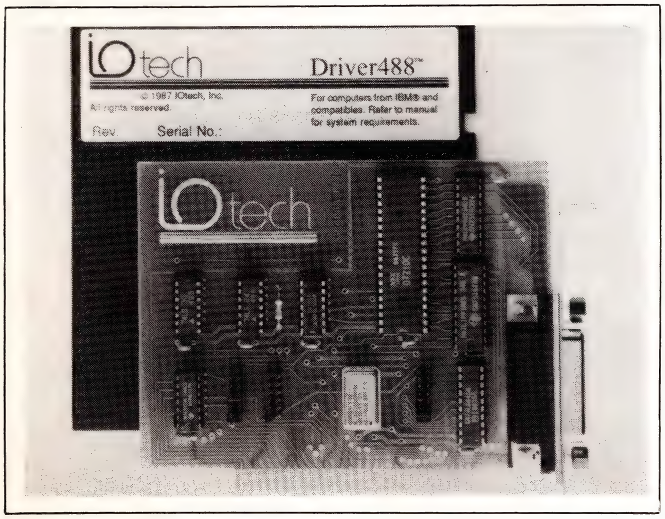
CIRCLE NO 149

READERS' CHOICE

Of all the new products covered in EDN's **March 18, 1987**, issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, find out what makes them special: Just circle the appropriate numbers on the Information Retrieval Service card, or refer to the indicated pages in our **March 18, 1987**, issue.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Driver488™
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For computers from IBM® and compatibles. Refer to manual for system requirements.
Rev.
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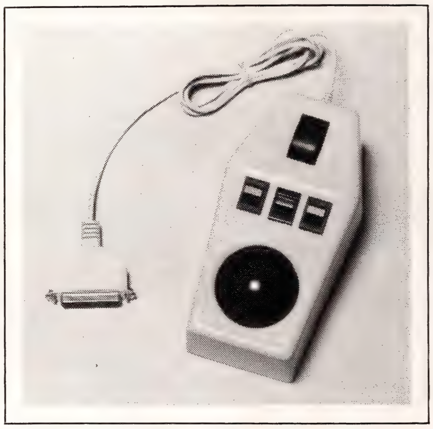
IOtech

▲ IEEE-488 PACKAGE

The Personal488 hardware and software package comprises an IEEE-488 board that plugs into an IBM PC, and software for that board (pg 254).

IOtech Inc.
Circle No 603



▲ TRACKBALL

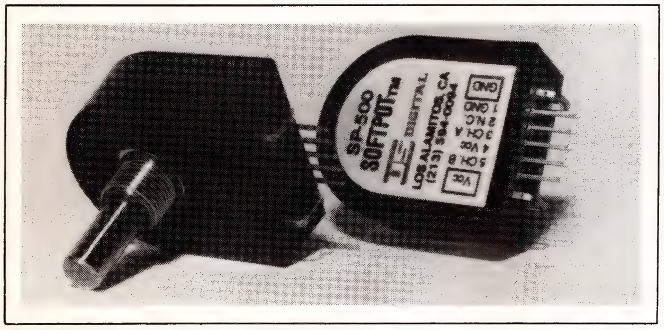
The FastTrap trackball is a 3-axis I/O pointing device that provides 3-dimensional cursor control at a resolution of 200 pulses/in. (pg 116).

MicroSpeed Inc.
Circle No 602

MULTITASKING FOR PC

PCMascot is a multitasking kernel for the IBM PC and compatibles. It allows you to develop real-time applications that use concurrently executing processes for process control or data acquisition (pg 260).

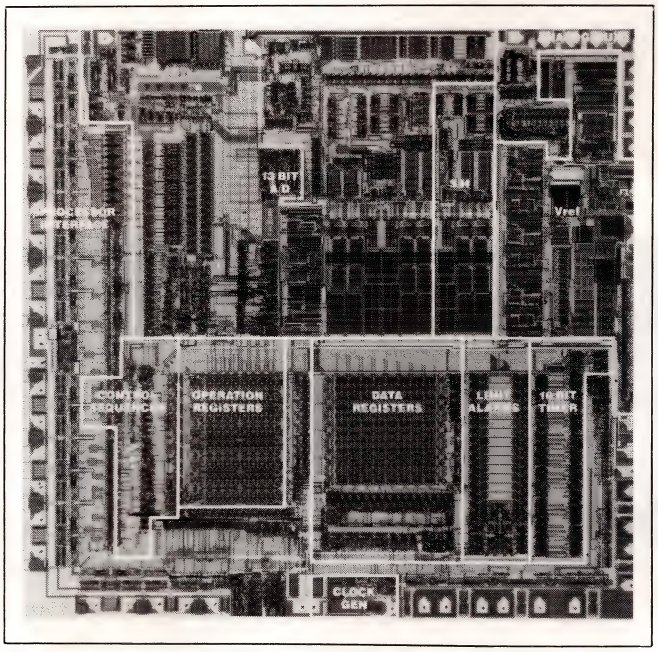
Andyne Computing Ltd.
Circle No 604



▲ OPTICAL ENCODERS

The SP-360, SP-500, and SP-512 optical encoders yield 360, 500, and 512 cycles/revolution, respectively, and draw less than 40 mA from a 5V supply (pg 223).

US Digital Corp.
Circle No 605



▲ DATA-ACQUISITION SYSTEM

The ML2200 low-power CMOS chip is a single-chip data-acquisition system that performs many of the tasks of a μP (pg 104).

Micro Linear.
Circle No 601

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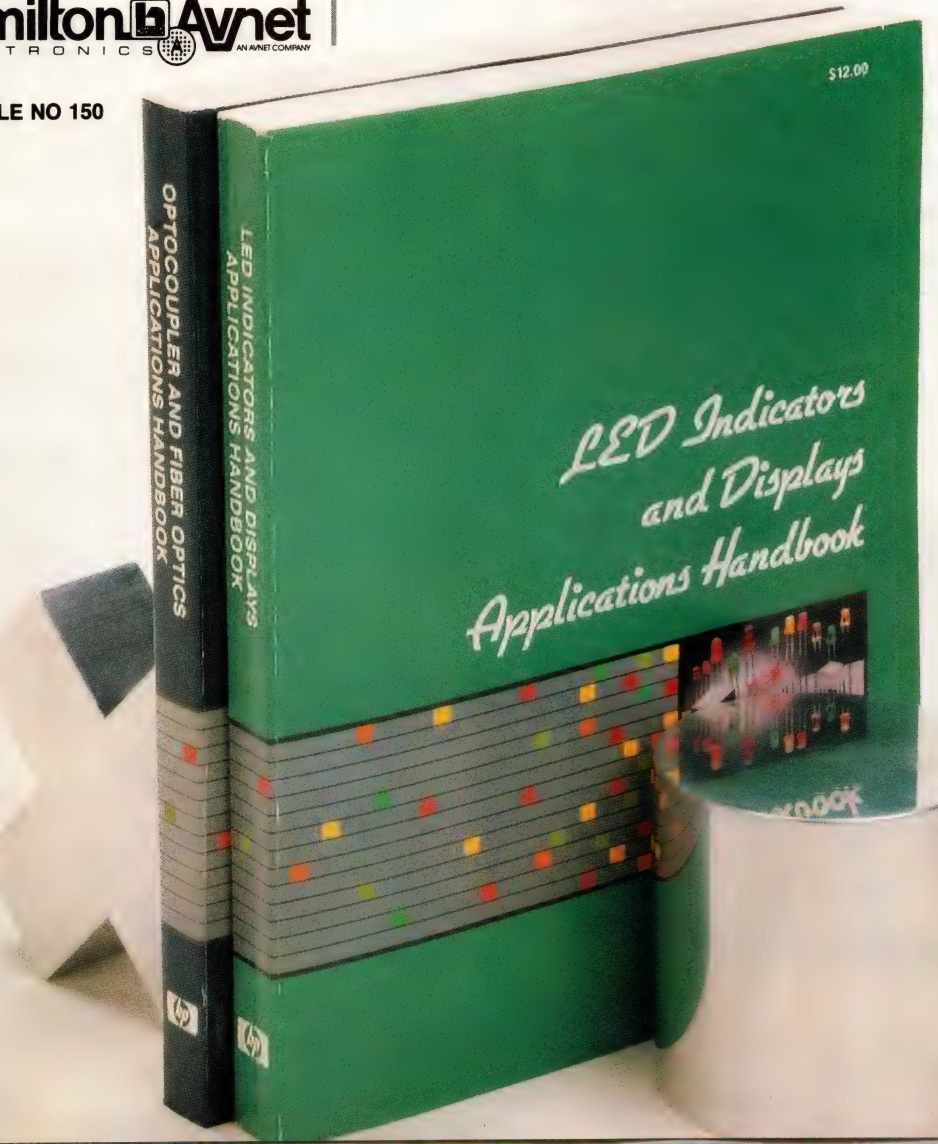
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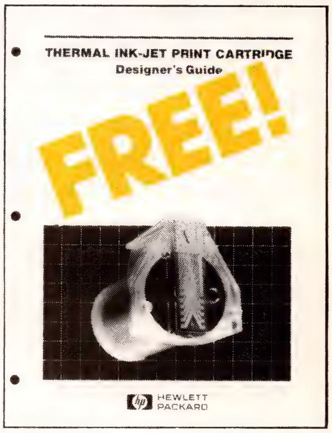
Just contact your local Hamilton/Avnet sales representative for more information. Or send in the coupon below and we'll give you a Thermal Ink-Jet Print Cartridge Designer's Guide, absolutely free!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CIRCLE NO 152

SAMSUNG Speaks

A NEWSLETTER FROM SAMSUNG SEMICONDUCTOR

VOLUME ONE, NUMBER TWO

Included in this issue:
▶ POWER MOSFETs ▶ DRAMs
▶ EEPROMs ▶ SRAMs ▶ SOT-23s
▶ AHCT/HCTLS CMOS LOGIC ▶ LINEAR ICs

DIRECT REPLACEMENT POWER MOSFETS

The competition has met its match.

Introducing direct replacement for IR and Motorola® MOSFETs. Samsung MOSFETs. The fastest, most rugged, most reliable MOSFETs in the industry. (2230 mJ at 500 v.)

We have the broadest product line of any supplier—over 300 part types in both P- and N-channels are available for immediate delivery, ranging from 60v. to 700v. In TO-3P, TO-220, TO-3 and TO-92L packages.

We are the first and only supplier to use bulk CMOS processing that delivers smaller die, higher yield, and lower cost. The entire family is supported by our technological partner, IXYS.

> *Samsung delivers higher performance, at lower price.*

So call your local Samsung sales office today. Ask for samples, a reliability report, or our new data book. Now you can replace IR and Motorola MOSFETs with something better. Samsung MOSFETs. ■

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SSH6N70
SSH4N70
SSH3N70
SSH15N60
SSH10N60
SSH8N60
SSH6N60
SSH4N60
SSH15N55
SSH10N55
SSH8N55
SSH6N55
SSH4N55
SSH20N50
SSH4N50
SSH20N45
SSH25N40
SSH25N35
SSH15N10
IRFP130
IRFP131
IRFP132
IRFP133
IRFP140
IRFP141
IRFP142
IRFP143
IRFP150
IRFP151
IRFP152
IRFP153
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IRFP453

P-Channel TO-3P
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IRFP9131
IRFP9132
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IRFP9230
IRFP9231
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IRFP9243

N-Channel TO-220
SSP6N70
SSP4N70
SSP3N70
SSP2N70
SSP6N60
SSP4N60
SSP2N60
SSP6N55
SSP4N55
SSP2N55
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P-Channel TO-220
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IRF9643

N-Channel TO-3
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SSM15N60
SSM10N60
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SSM4N60
SSM15N55
SSM10N55
SSM8N55
SSM6N55
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IRF9240
IRF9241
IRF9242
IRF9243

N-Channel TO-92L
IRFL1Z0
IRFL1Z3

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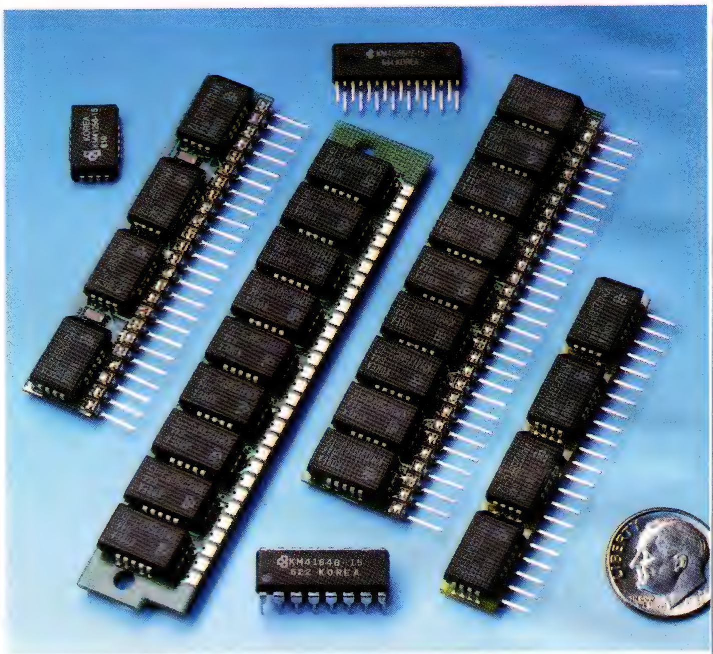
CIRCLE NO. **165**

Nobody is moving faster in memory technology development than Samsung.

Samsung now offers an extensive line of memories: DRAMs, EEPROMs and SRAMs. We are among the industry leaders, producing high quality, highly reliable memory products. Our industry-standard pin-for-pin compatible memories are all proprietary products of our own design, developed in our state-of-the-art R&D facility, utilizing our own technology and processing.

We are determined to be your long term memory supplier. Our production facilities are internationally recognized as being among the most advanced in the world. Samsung is one of the few semiconductor companies fabricating 6-inch wafers in production quantities. This advanced processing technology allows us to keep costs down and volume up.

Samsung's commitment to winning the memory game is underscored by the $600 million we're investing in memory product development and by our new 80,000 square foot headquarters in San Jose, staffed by our 160 person R&D team. This R&D facility has the ultimate in Class-1 clean room technology. A unique vertical laminar flow process helps us control every aspect of the fab environment to achieve the industry's most exacting quality standards. ■



DRAMs

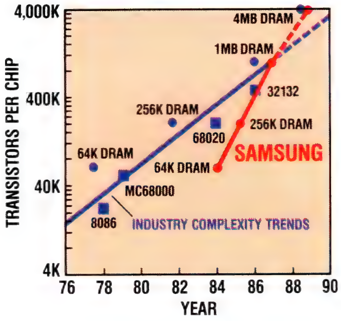
You can see how fast our DRAM technology is progressing in the graphs on the right.

Our 64K and 256K DRAMs are all available in production quantities now. You will be able to get engineering samples of our 1MB DRAM this quarter, qualification samples will be available in mid 1987 with production ramp starting in the third quarter.

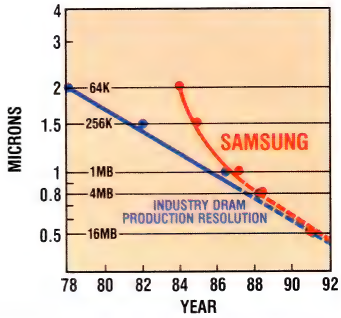
Samsung now offers every major DRAM part type.

We're not stopping at 1-million bits. Our 4MB DRAM development program is right on track. Engineering samples will be available early next year.

Samsung DRAM Development



DRAM Production Resolution



Samsung DRAMs are available in the most effective size, speed and organization combinations. Scan the chart below to find the right DRAMs for your applications.

You can see from the picture that we package our DRAMs the way you want them: DIP, PLCC, SIP/SIMM and ZIP.* If you're looking for state-of-the-art, check out our 256 x 8 (or x 9) SIP and SIMM memory modules.

We have the technology, we have an aggressive memory development program in place and we have the memory products to meet your requirements, available now. Samsung is committed to being your memory supplier. Call your nearest Samsung sales office for samples and data sheets, today. ■

*Q3

CIRCLE NO. **166**

DRAMs

Density	64K	256K	256K	1 Mb	1 Mb
Organization	64Kx1	256Kx1	64Kx4	1Mx1	256Kx4
Availability	Now	Now	Now	Q3'87	Q3'87
Technology	NMOS	NMOS	NMOS	CMOS	CMOS
Package	DIP	DIP, PLCC, SIP/SIMM, ZIP*	DIP, PLCC, SIP/SIMM, ZIP*	SOJ, SIP/SIMM, ZIP	SOJ, SIP/SIMM, ZIP
Speed	150 ns, 200 ns	120 ns, 150 ns	120 ns, 150 ns	80 ns, 100 ns, 120 ns	80 ns, 100 ns, 120 ns
Mode	Page	Page, Nibble	Page	Static Column Page, Nibble	Page

*Q3 '87

EPROMs

Samsung 16K and 64K EEPROMs meet or exceed industry standards. Endurance is rated at 10,000 erase/write cycles. Data retention ratings are 10 years for our entire line. Moreover, our pin-out permits you to upgrade EEPROMs without re-designing your entire PCB. Most importantly, our EEPROMs are immediately available.

When it comes to EEPROMs, we deliver.

We offer industrial temperature operating range (−40° to +85°C) and high performance 64K KM2864AH and KM2865AH EEPROMs. They feature write cycle times that are five times faster than standard parts.

Samsung is known for reliability, quality and performance. And nobody beats our EEPROM prices. See for yourself. Call your Samsung sales office to get our EEPROM reliability report, data sheets or samples. 🟥

CIRCLE NO. **167**

EEPROMs

Density	16K	16K	64K	64K	64K	64K
Part Number	KM2816A	KM2817A	KM2864A	KM2864AH	KM2865A	KM2865AH
Availability	Now	Now	Now	Now	Now	Now
Package	24 Pin Plastic DIP	28 Pin Plastic DIP	28 Pin Plastic DIP	28 Pin Plastic DIP	28 Pin Plastic DIP	28 Pin Plastic DIP
Speed	250 ns, 300 ns, 350 ns	250 ns, 300 ns, 350 ns	200 ns, 250 ns, 300 ns	200 ns, 250 ns, 300 ns	200 ns, 250 ns, 300 ns	200 ns, 250 ns, 300 ns
Endurance	10,000 Erase/Write Cycles	10,000 Erase/Write Cycles	10,000 Erase/Write Cycles	10,000 Erase/Write Cycles	10,000 Erase/Write Cycles	10,000 Erase/Write Cycles
End of Write Scheme		RDY/$\overline{\text{BSY}}$	$\overline{\text{Data}}$ Polling	$\overline{\text{Data}}$ Polling	RDY/$\overline{\text{BSY}}$, Data Polling	RDY/$\overline{\text{BSY}}$, Data Polling
Byte Write Time	10 ms write/byte	10 ms write/byte	10 ms write/byte	2 ms write/byte	10 ms write/byte	2 ms write/byte

SRAMs

Samsung is making the same commitment to SRAMs that we make to all our memory products. Samsung is increasing Static RAM production rather than cutting back the way some other manufacturers are. And we are expanding our SRAM line as we develop the next generation 256K and fast 64K CMOS Static RAMs. Check our offerings in the chart below. Then call your Samsung sales office for samples and data sheets. Make Samsung your quality SRAM supplier. 🟥

CIRCLE NO. **168**

SRAMs

Density	64K	64K	64K	64K
Part Number	KM6264-12	KM6264-15	KM6264L-12	KM6264L-15
Organization	8Kx8	8Kx8	8Kx8	8Kx8
Availability	Q4	Now	Q4	Now
Technology	MIX-MOS	MIX-MOS	MIX-MOS	MIX-MOS
Package	28 Pin DIP	28 Pin DIP	28 Pin DIP	28 Pin DIP
Speed	120 ns	150 ns	120 ns	150 ns
Standby Current	1 mA Max.	1 mA Max.	100 μA Max.	100 μA Max.

Samsung's 54/74 AHCT and 54/74 HCTLS CMOS Logic gives you the most comprehensive selection of LS, ALS and FAST™ replacements. 61 parts now–86 more in Q3.

Replace LS, ALS and FAST with AHCT and HCTLS CMOS logic parts from Samsung—right now. Look at the advantages we can offer you. And at prices comparable to bipolar!

Comparison of Key Parameters for a 244 Octal Buffer

	74AHCT	74HCTLS	74ALS	74LS	74ACT*
Max Propagation Delay ($C_l = 50pF$)	10ns	18ns	10ns	18ns	13.5ns
Drive Current, I_{OL}	24mA	24mA	24mA	24mA	24mA
Power Dissipation (at 100KHz)	0.6mW	0.6mW	70mW	120mW	1mW

*Fairchild FACT™

You get low power, wide operating supply and temperature ranges, superior noise immunity, rail-to-rail output voltage swings and the low input currents of CMOS, combined with the high speed and drive capability of bipolar.

Unlike older performance-limited HC and HCT logic families, Samsung's high performance CMOS logic matches bipolar speed and drive. 24 mA is guaranteed. Moreover, our CMOS logic allows you to interface directly with all types of TTL, NMOS and CMOS circuitry.

Compare the power dissipation of Samsung's AHCT/HCTLS logic to bipolar LS/ALS/FAST. Our logic consumes 100,000 times less power at low frequencies and 10 times less power at 10 MHz. CMOS voltage swings also give you up to three times the noise immunity.

Ask us and we'll send you two free samples each of up to five part types. Just call your local Samsung sales office and specify AHCT or HCTLS with your part number. Use this list to order your samples and to see what's coming later this year. Take advantage of Samsung's cool running, highly reliable, high performance CMOS logic.

Order your free samples today.

(continued on next page)

CIRCLE NO. **169**

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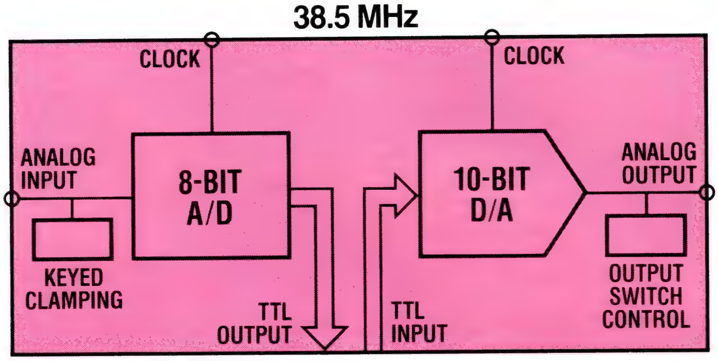
For product information call your local Samsung sales office.

SAMSUNG SAYS SO.

Flash Converter features independent 8-bit A to D and 10-bit D to A functions on a single chip.



The new KSV3100A flash converter is the latest and most impressive addition to Samsung's extensive line of linear products. The monolithic KSV3100A provides independent 8-bit flash A/D converter and 10-bit R-2R D/A converter functions over an operating range of DC to 38.5 MHz.

The single-chip architecture of the KSV3100A allows you to design-in with a single board rather than many. This saves real estate and gives you room to add more features to your system. Using fewer parts also raises the reliability of your system.

Samsung has designed a number of useful features into our new flash converter. You can choose between selectable peak level or keyed clamping. And the device's absolute non-linearity is rated at 1 per cent.

We also provide you with the support chips you need. Our KA2606 Sync Separate IC, KA2153 Chrominance Signal Processor for NTSC systems, and KA2154 Video Chroma Deflection System for NTSC and PAL systems make it easy to integrate the KSV3100A into your video applications.

Samsung's flash converter prices are unbeatable. The chart shows our 100 piece KSV3100A Flash Converter prices:

KSV3100 AN – 10	$48.90	KSV3100 AN – 8	$24.45
KSV3100 AN – 9	$32.60	KSV3100 AN – 7	$14.67

CIRCLE NO. **170**

CMOS LOGIC *(Continued)*

KS/74AHCT & KS/74HCTLS Part Types

Gates & Inverters
00
01
02
03
04
05
08
09
10
11
12
14*
20*
21*
22*
27*
32
51*
58*
86
132*
133*
266

Buffers & Line Drivers
125*
126*
210
240
241
244
365
366
367
368
465*
466*
467*
468*
540
541

Flip-Flops
73*
74
76*
78*
107
109
112
173*
174
175
273
374
377*
399*
534
564
574
670*
794*
821*
822*
823*
824*
825*
826*

Latches
259*
373
533
563
573
793*
841*
842*
843*
844*

Transceivers/Registered Transceivers
242*
243*
245
640
643
645
646
648
651*
652*
658*
659*
664*
665*

Counters
160
161
162
163
168*
169*
191*
193*
390*
393
590*
591*
592*
593*

Decoders/Encoders
42*
138
139
148*
154*
155*
238
239

Multivibrators
121*
123*
423*

Multiplexers
151*
153*
157
158
251*
253*
257
258
352*
353*

Shift Registers
164
165*
166
194*
195*
299*
595*
596*
597*

Arithmetic Circuits
280*
518*
519*
520*
521*
522*
679*
680*
682*
684*
686*
688*
689*

*Part Types Available in Q3—All Other Part Types Available Now.

CIRCLE NO. **169**

SOT-23s

Samsung has the SOT-23s you're looking for: industry standard NPN and PNP epitaxial transistors implemented in the internationally standardized micro-package.

Samsung SOT-23s are ideal for both hybrid and surface mounting. Our SOT-23 micro-packaging saves real estate, slashes costs and boosts system reliability.

We also offer a broad range of TR products: industry standard TIP-series power transistors, high-speed high-voltage switching power transistors, power Darlington transistors and our TO-3P silicon mesa transistors—they're rated at 1500 Volts!

Call your Samsung sales office for our SOT-23s or New Transistor data book. ■

CIRCLE NO. **171**

LINEAR ICs

Samsung offers a full line of linear products, in addition to converters, including: amplifiers, timers, regulators, comparators, telephone ICs, power amplifiers and a number of other ICs.

Samsung's entire line of standard parts is now available in production quantities. A number of our key linear offerings are listed below:

Data Conversion

KS7126	3½ Digit CMOS A/D Converter
KS25C02	8 bit CMOS Successive Approx. Register
KS25C03	8 bit CMOS Successive Approx. Register
KS25C04	**12 bit CMOS Successive Approx. Register**

Voltage Regulators
MC78xx
MC78Mxx
MC78Lxx
MC79xx
MC79Mxx
LM317T
µA78S40

Op Amps
LM741
MC1458
MC4558
LM358/A
LM348
LM324/A
MC3403

Timers
KS555 (CMOS)
NE555
NE556
NE558

Comparators
LM311
LM393/A
LM339/A

Interface
MC1488
MC1489/A

Tone Decoder
LM567
LM567L (Micropower)

Telephone

KA2410	Tone Ringer
KA2411	Tone Ringer
KA2412A	Speech Network
KA2420	**Speaker Phone**
KA2413	DTMF
KS5808	DTMF
KS5805A/B	Pulse Dialer

Others

KS5803A/B	IR Transmitter
KA2181	IR Preamplifier
KA2182	IR Preamplifier
KA2183	IR Preamplifier
MC3361	FM IF Amplifier
KA2803	Ground Fault Detector
KA2084	Zero Voltage Switch
LM386	**Audio Power Amplifier**

Call your local Samsung sales representative for a Data Book that includes our Cross Reference Guide and samples. ■

CIRCLE NO. **172**

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CA	Samsung Semiconductor	(714) 662-3406
CA	SYNPAC	(408) 988-6988
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SAMSUNG
Semiconductor
5150 Great America Parkway
Santa Clara, CA 95054

LEADTIME INDEX

Percentage of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
TRANSFORMERS								
Toroidal	0	29	57	14	0	0	7.6	8.6
Pot-Core	0	25	63	12	0	0	7.7	9.6
Laminate (power)	11	28	61	0	0	0	5.7	8.1
CONNECTORS								
Military panel	0	40	40	20	0	0	7.5	10.8
Flat/Cable	20	47	27	6	0	0	4.6	6.6
Multipin circular	13	12	25	50	0	0	10.1	7.3
PC	20	30	50	0	0	0	4.9	6.4
RF/Coaxial	17	33	50	0	0	0	5.0	7.9
Socket	30	45	15	10	0	0	4.1	4.5
Terminal blocks	29	53	18	0	0	0	3.0	4.3
Edge card	36	14	43	7	0	0	5.0	6.0
Subminiature	33	22	45	0	0	0	4.2	6.2
Rack & panel	29	18	43	0	0	0	4.3	5.5
Power	20	50	30	0	0	0	3.9	5.4
PRINTED CIRCUIT BOARDS								
Single-sided	0	82	18	0	0	0	3.9	6.0
Double-sided	0	46	54	0	0	0	5.7	6.1
Multilayer	0	27	67	6	0	0	7.2	8.7
Prototype	9	81	10	0	0	0	3.2	4.9
RESISTORS								
Carbon film	48	28	24	0	0	0	2.8	5.0
Carbon composition	50	29	14	7	0	0	3.1	5.3
Metal film	47	21	21	11	0	0	3.9	6.2
Metal oxide	33	33	34	0	0	0	3.7	5.4
Wirewound	12	47	35	6	0	0	5.1	6.9
Potentiometers	22	35	30	13	0	0	5.5	6.8
Networks	36	21	21	22	0	0	5.7	7.9
FUSES	50	28	22	0	0	0	2.6	4.1
SWITCHES								
Pushbutton	24	33	29	9	5	0	6.0	5.5
Rotary	19	25	44	12	0	0	6.2	7.3
Rocker	29	43	21	7	0	0	4.1	4.6
Thumbwheel	10	40	40	10	0	0	6.0	6.4
Snap action	25	17	42	8	8	0	7.3	5.1
Momentary	10	40	30	10	10	0	7.7	7.4
Dual in-line	20	40	20	0	20	0	7.9	6.8
WIRE AND CABLE								
Coaxial	36	37	18	9	0	0	4.0	4.8
Flat ribbon	39	44	11	6	0	0	3.1	5.0
Multiconductor	44	19	37	0	0	0	3.6	4.8
Hookup	64	27	9	0	0	0	1.5	1.9
Wire wrap	73	18	9	0	0	0	1.3	2.8
Power cords	18	47	29	6	0	0	4.7	4.5
Other	0	0	100	0	0	0	8.0	6.0
POWER SUPPLIES								
Switching	12	31	38	19	0	0	6.8	9.4
Linear	10	40	40	10	0	0	6.6	8.6
CIRCUIT BREAKERS	15	31	39	15	0	0	6.4	5.4
HEAT SINKS	26	63	11	0	0	0	2.7	6.0

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
RELAYS								
General purpose	30	35	25	10	0	0	4.6	5.6
PC board	10	42	32	16	0	0	6.2	7.9
Dry reed	0	50	38	12	0	0	6.4	7.9
Mercury	0	33	67	0	0	0	6.3	10.1
Solid state	13	27	47	13	0	0	6.6	7.9
DISCRETE SEMICONDUCTORS								
Diode	42	23	31	4	0	0	3.8	6.3
Zener	41	18	29	12	0	0	4.7	6.9
Thyristor	13	37	38	12	0	0	6.1	8.3
Small signal transistor	31	23	38	8	0	0	5.0	7.6
FET, MOS	29	36	21	7	7	0	5.7	6.9
Power, bipolar	17	50	33	0	0	0	4.2	6.4
INTEGRATED CIRCUITS, DIGITAL								
CMOS	24	38	29	9	0	0	4.9	7.1
TTL	36	27	32	5	0	0	4.1	6.3
LS	35	35	25	5	0	0	3.8	6.8
INTEGRATED CIRCUITS, LINEAR								
Communication/circuit	8	33	42	17	0	0	6.9	8.2
OP amplifier	23	15	54	8	0	0	6.0	7.3
Voltage regulator	20	30	45	5	0	0	5.3	6.6
MEMORY CIRCUITS								
RAM 16k	25	42	33	0	0	0	3.9	7.1
RAM 64k	25	42	25	8	0	0	4.5	5.8
RAM 256k	27	46	18	9	0	0	4.2	8.2
ROM/PROM	27	46	27	0	0	0	3.5	6.7
EPROM	25	44	12	19	0	0	5.2	6.0
EEPROM	20	40	40	0	0	0	4.4	8.5
DISPLAYS								
Panel meters	10	30	50	10	0	0	6.5	8.2
Fluorescent	20	20	20	40	0	0	8.4	11.2
Incandescent	0	25	75	0	0	0	6.8	8.6
LED	25	25	40	10	0	0	5.5	6.4
Liquid crystal	12	31	38	19	0	0	6.8	9.6
MICROPROCESSOR ICs								
8-bit	29	28	43	0	0	0	4.3	7.8
16-bit	40	20	40	0	0	0	3.8	8.2
FUNCTION PACKAGES								
Amplifier	33	17	33	17	0	0	5.8	11.8
Converter, analog to digital	11	33	45	11	0	0	6.3	7.0
Converter, digital to analog	14	14	57	15	0	0	7.2	7.7
LINE FILTERS	22	22	56	0	0	0	5.1	8.3
CAPACITORS								
Ceramic	42	26	26	6	0	0	3.7	4.9
Ceramic monolithic	41	29	24	6	0	0	3.7	4.6
Ceramic disc	47	29	18	6	0	0	3.2	4.1
Film	44	11	45	0	0	0	3.9	5.0
Electrolytic	25	35	25	15	0	0	5.4	5.2
Tantalum	26	35	35	4	0	0	4.5	6.3
INDUCTORS	12	38	38	12	0	0	6.1	7.6

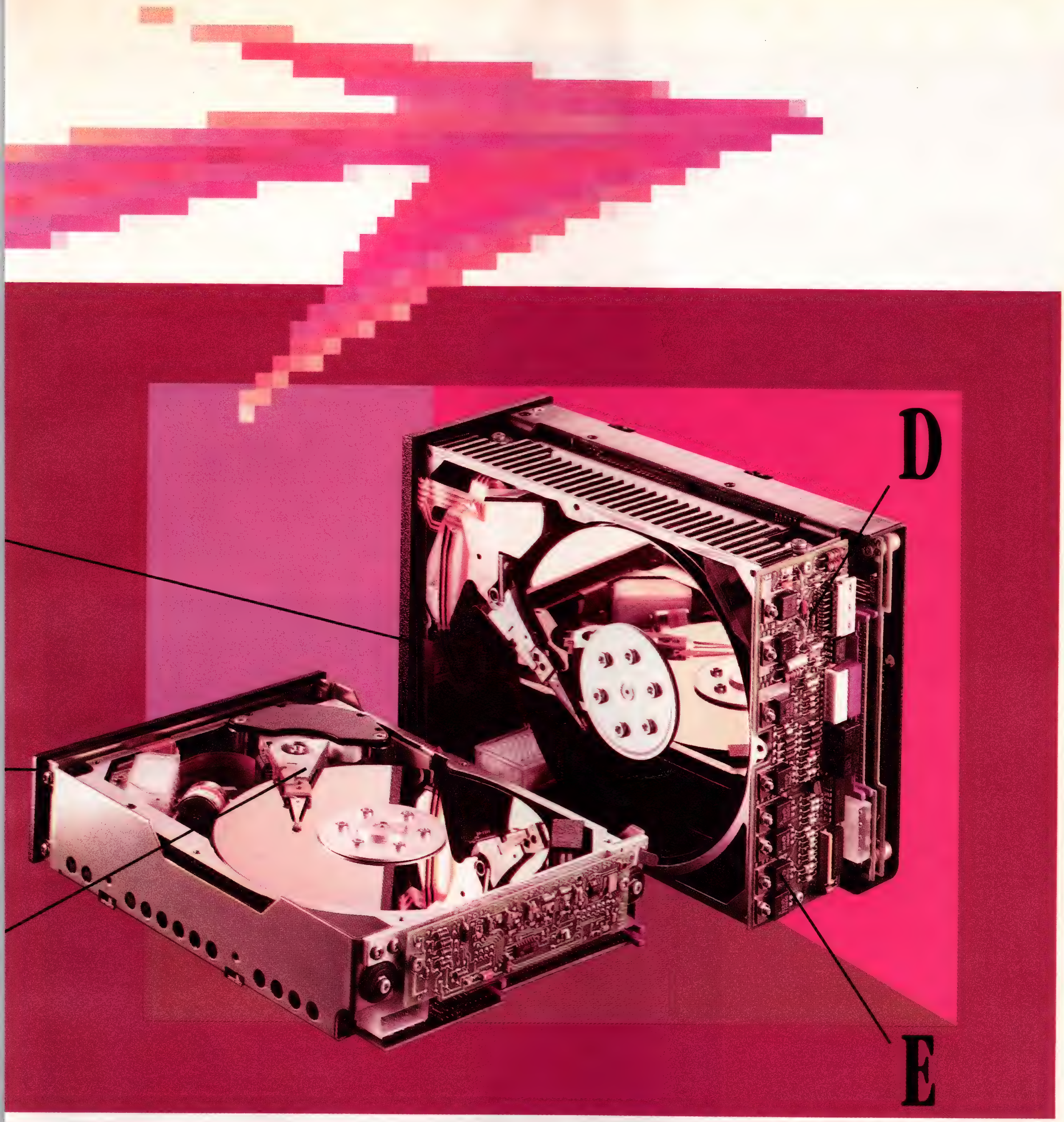
Source: *Electronics Purchasing* magazine's survey of buyers

0 TO 60 IN 16.5 MILLISECONDS.

That's faster than any other 5 ¼ ″ disk drive on the market. And, 16.5 ms is just the average seek time for the Wren IV.

What's more, like all Wren disk drives, it's built for the long run as well as the sprint. We're talking endurance–30,000 hour MTBF endurance.

Speed, endurance, and Control Data's outstanding quality–that's the Wren. And, there's more. **A** The Wren IV provides 300 Mbytes of formatted capacity along with a swift 16.5 ms seek time. **B** The Wren III Half-High provides 101 Mbytes of unformatted storage. **C** Wren's patented straight-arm actuator employs substantially less mass than other designs and operates with superior positioning precision and speed. **D** Both models feature a full function SCSI interface. Other interfaces available on selected Wren models include ESDI and ST506. **E** Advanced electronics packaging, low power consumption,



and special shock mounts are just a few of the reasons why Wren also wins the endurance race.

We've been building reliable data storage products for over 28 years. In fact, no one has built more high-performance, high capacity disk drives than Control Data.

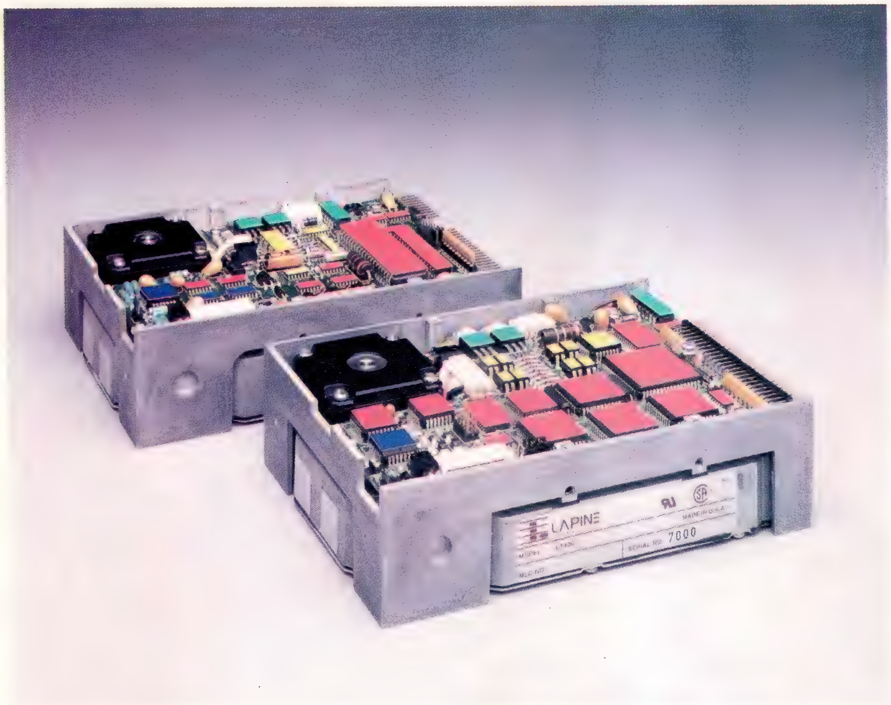
For more information, call 1-800-828-8001, ext. 82 (In Minnesota, call 612-853-3400, ext. 82) or call your local Arrow or Kierulff distributor.

	Full High		Half High		Both	
Model	Capc.	Avg. Seek	Capc.	Avg. Seek	Transfer Rate	Interface Options
Wren II	86	28	51	28	5	ST506, (ESDI F.H. only)
Wren III	182	16.5	101	18	10	ESDI, SCSI
Wren IV	300	16.5	To be Announced		10-15	SCSI

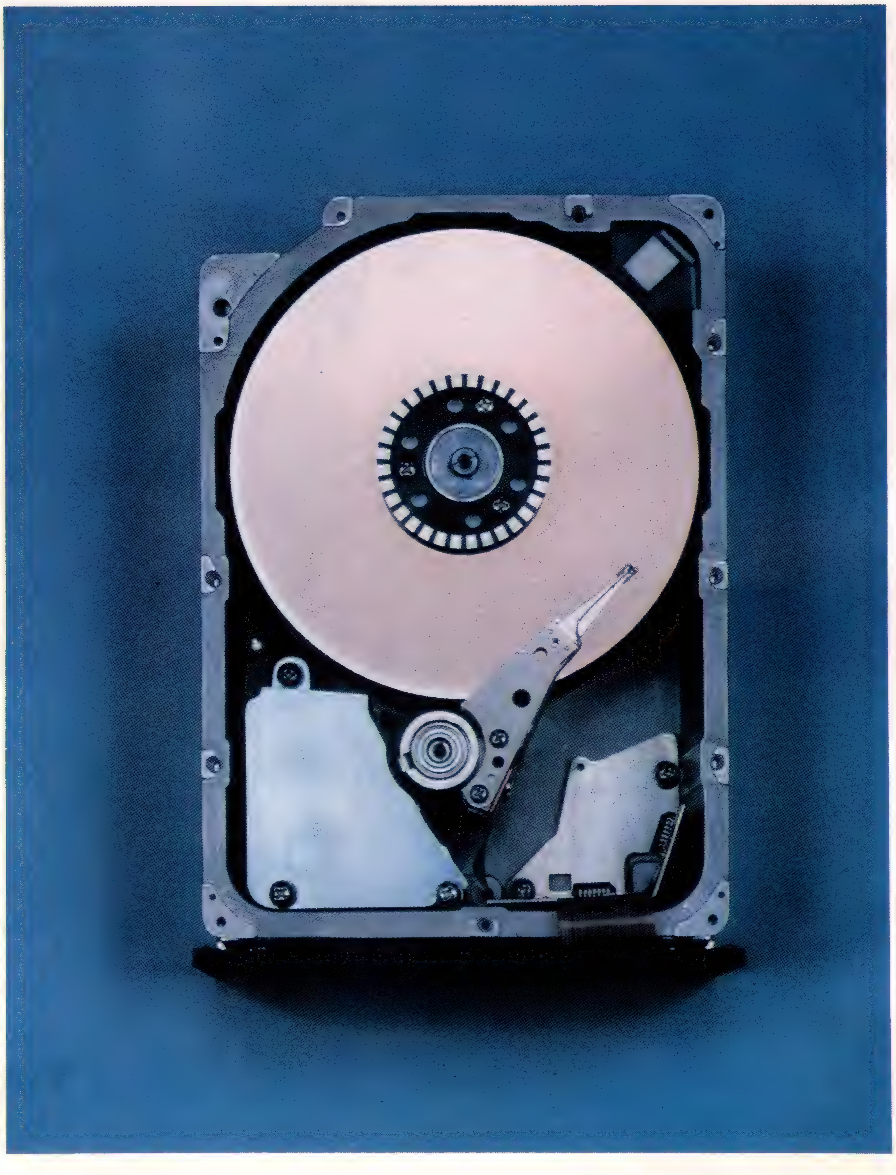
To learn more about Control Data's complete line of high-performance data storage products, give us a call.

CONTROL DATA

CIRCLE NO 153



Embedding a SCSI controller on a Winchester disk drive requires increased density *on the pc board mounted on the drive's head/disk assembly, as Lapine's 40M-byte Titan drives demonstrate. The drive in the background implements an ESDI interface; the unit in the foreground has an embedded SCSI controller. The components on the boards are color-coded: the yellow areas perform stepper-motor control, the green parts handle spindle-motor control, the blue parts are the data channels, and the red areas are the controllers. As you can see, the intelligent embedded-SCSI controller requires substantially more components than does the device-level ESDI controller.*



The straight-arm rotary actuators *used in Quantum's Q200 family help reduce the drives' average seek time to 26 msec. The line of products includes half- and full-height 5¼-in. units having formatted capacities ranging from 53M to 160M bytes.*

Embedded-SCSI Winchesters

The SCSI intelligent I/O bus permits the use of a wide variety of disk drives and other peripherals in minicomputer and microcomputer systems. By offering improved performance at reasonable prices, the latest embedded-SCSI Winchesters make it easier than ever for you to implement the SCSI bus in your designs.

Designing a mass-storage I/O subsystem for a minicomputer or microcomputer system is no longer just a simple matter of choosing a disk drive. Now that embedded-SCSI Winchester disk drives are widely available and competitively priced, they provide a feasible alternative to drives with device-level interfaces (**Refs 1, 2,** and 3). To see whether an embedded-SCSI drive will suit your application, however, you need to think in terms of system performance as well as the performance of the disk drive.

Using a SCSI-based I/O subsystem in your minicomputer or microcomputer system is appealing for a number of reasons. Because it moves intelligence to peripherals, the Small Computer System Interface (SCSI) fits well into the emerging computer architectures that stress distributed intelligence. Multitasking, multiuser systems are also likely to benefit from a SCSI implementation. And if you want to link different peripherals through one I/O channel, you might even choose SCSI for single-user, single-tasking systems.

The SCSI bus provides a single interconnection to a wide variety of peripherals, and it can even serve as a very local-area network (the total cable length connecting all devices on the bus is limited to 20m) with multiple hosts.

Further, although you use an extra layer of I/O-bus hardware (the host adapter) to implement SCSI in a host system, cost is really no longer an issue when you're deciding whether or not to choose SCSI. The cost of implementing the host adapter has decreased greatly in relation to system cost, to the point where it's not a major consideration for most workstations, minicomputers, or even high-end PCs. What's more, SCSI's benefits—for example, the fact that it can provide faster system performance and allow for an operating system with device-independent drivers—far outweigh the drawbacks.

In light of these advantages, many microcomputer and minicomputer vendors have chosen to use SCSI. Joe Molina, president of Technology Forums Ltd (Pomona, CA), which produces conferences on state-of-the-art technology, predicts that by 1990, worldwide shipments of embedded-SCSI Winchesters will (at minimum) exceed

- 2.5 million 3½-in. drives
- 750,000 half-height 5¼-in. drives
- 100,000 full-height 5¼-in. drives
- 25,000 8-in. drives.

Molina expects the OEM revenue from such shipments to exceed one billion dollars.

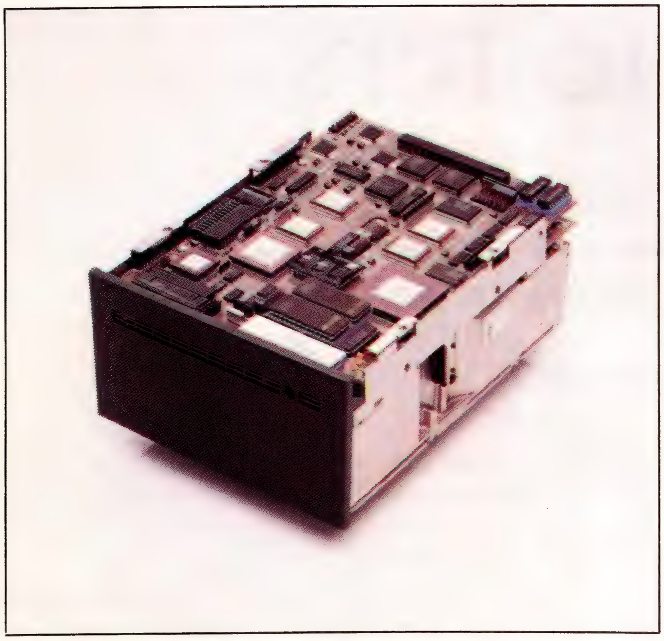
Embedded-SCSI drives' performance rises

Because the most recent embedded-SCSI Winchesters demonstrate increased performance without an increase in price, it's now easier than ever to implement the SCSI bus in your system designs. These newer drives feature higher data-transfer rates and less command overhead than the first embedded-controller drives did. And embedded-SCSI Winchester drives now cost about the same as Winchesters with device-level interfaces do.

To embed SCSI functions in the drives and to increase both the size of the buffers on the controllers and the overall performance of the drives, manufacturers used the new controller-specific VLSI ICs. The VLSI components have also allowed vendors to embed a

Maury Wright, *Regional Editor*

To evaluate SCSI drives, you must consider system performance, data integrity, compatibility, flexibility, test issues, and HDA characteristics.



A synchronous SCSI data-transfer rate of 2.5M bytes/sec *allows the Fujitsu M2200-family drives to minimize the amount of time during which they tie up the I/O bus. The drive family employs oxide media and ferrite heads, yet includes a product with an unformatted capacity of 389M bytes.*

controller in the available pc-board real estate of a 3½-in. drive.

In fact, all the performance enhancements of embedded-SCSI Winchesters are attributable to VLSI. The increase in the drives' capacity, however, is due to other innovations and techniques. For example, the data surfaces (or platters) now have greater area density (number of bits/in^2), so they allow you to put bits or tracks closer together on the disk. Further, both the electronics used in the read channel and the servo electronics that control the voice-coil motor are faster and more accurate in the new drives.

In the head-disk assembly (or HDA), manufacturers have added platters and increased capacity. Maxtor leads the way with an 8-platter, 5¼-in., full-height drive that stores 601.6M bytes (formatted), and a 5-platter 3½-in. drive that stores 142.3M bytes (formatted).

Although the specs for a drive's head/disk assembly and data channel are important, when you're evaluating a SCSI drive it's actually more important to consider the way the manufacturer implemented SCSI in the drive. To decide whether an embedded-SCSI disk drive is right for your next design, or to choose a drive for a SCSI design, you must give thought to a number of interface-related issues such as performance, compatibility, flexibility, data integrity, and evaluation and testing of the drives you're considering.

You'll also find that embedded-SCSI drives have specs that differ from those of drives with device-level interfaces. For example, most vendors quote formatted capacity for embedded SCSI drives, and except where noted otherwise, this article lists SCSI drives' formatted capacity. This specification makes sense: Because the SCSI controllers are embedded in these drives, you can't vary the drive's format by choosing a different controller, as you can with drives that use separate controllers. It's the controller that determines exactly how the format is implemented, thus determining the drive's usable capacity. (**Table 1,** which begins on pg 138, lists these and other specifications for the available embedded-SCSI Winchester disk drives.)

Embedded-SCSI-drive manufacturers also tend to quote average seek time instead of average access time, because the average-access-time spec includes command overhead. For drives with device-level interfaces, which have no command overhead, manufacturers often use the seek-time and average-access-time specs interchangeably, because they're virtually the same for these drives. The distinction is important for SCSI drives, however, which do have command overhead.

As with other drives, an embedded-SCSI drive's performance is of primary importance both in considering whether or not to use SCSI and in choosing a particular drive. Unlike non-SCSI systems, however, a SCSI system's performance depends on more than just the drive's data rate and access time.

First of all, the access-time spec for a SCSI Winchester isn't straightforward; it's affected by the drive's command-interpretation (or command-decode) time. The command-interpretation-time spec basically defines the amount of time the embedded controller uses between receiving a command and taking action on the command.

No standard method of measuring and specifying command-interpretation time exists, so just knowing the spec isn't enough. One vendor might specify the command-decode time for the execution of relatively simple commands; another might give the spec for the execution of more complex ones. If performance is an important consideration for your application, you'll want to make sure you ask manufacturers what they measure to obtain the command-decode times they specify. For information on benchmarking command-interpretation time, see **Ref 4.**

In the earlier bridge-controller and embedded-controller boards, command-interpretation times have ranged to as much as 10 msec. Average seek times for Winchesters range from 15 to 80 msec, so a 10-msec seek overhead is prohibitive for many applications. Some vendors do not provide a command-interpretation-time spec, and in that case, you'll have to evaluate a drive's performance before selecting it.

Some of the newer embedded SCSI controllers have a command-interpretation time of less than 1 msec. For example, the 174M-byte Model 2200 and the 261M-byte 2300 from Siemens feature 470-µsec command-interpretation times. Fujitsu's M2200 family of drives, which spec unformatted capacities of 86M to 389M bytes, have 600-µsec command-decode times. All of Maxtor's SCSI products, which range to the 601.6M-byte XT-8760S, and include the new 3½-in., 142.3M-byte LXT-170, spec decode times of 850 µsec. Finally, the 89M-byte, 5¼-in., half-height HH-1080 from Microscience features a 950-µsec decode time.

To achieve these reduced command-decode times, manufacturers use faster ICs and implement more efficient firmware. Most drive vendors purchase application-specific controller chips from controller-board vendors, such as Adaptec (Milpitas, CA), SMS/OMTI (Mountain View, CA), and Western Digital (Irvine, CA). The drive manufacturers are also using faster µPs and faster memory.

Fortunately for the customer, the decreasing prices of VLSI ICs are allowing the embedded-SCSI-drive vendors to include newer, faster chips without charging premiums for their drives. By incorporating VLSI components in its drives, Seagate offers 2-msec command-decode times even on its sub-100M-byte commodity drives, including the 3½-in. models, but the prices for its drives remain between $410 and $1625. The company will soon begin shipping new products that have interpretation times of less than 1 msec.

Arbitration and commands add delays

Factors other than a drive's command-decode time also add to the system overhead associated with the SCSI bus. For example, the host must arbitrate for the bus and then transfer a command to the peripheral. If the peripheral disconnects, it must go through the arbitration process before reconnecting and transmitting data. The SCSI host adapter must also set up command and data transfers, but it adds virtually no more delay than does a host-resident controller.

A linear actuator and offset heads *allow Priam to stack eight platters in its 700 Series drive, yet still use a spindle motor outside the spindle hub. The full-height drives range in formatted capacity from 166M to 357M bytes.*

Especially when you're considering SCSI overhead, you should think of SCSI in terms of system performance. SCSI provides the facility to establish multiple threads in an I/O subsystem. Threads are logical connections between the host and the drive. When more than one peripheral is on the bus, several logical threads or tasks may be active in the subsystem. Only one thread can physically use the bus at one time, but several electromechanical devices such as disk or tape drives can be working on commands at once.

Jim Rubino, director of systems development at Lapine Technology, believes designers will become familar with the term "virtual performance." Because a SCSI implementation isolates the host from the drive, you can make the drive's virtual performance better than the electromechanics would ordinarily allow. Lapine, for example, includes an 8k-byte buffer in its 3½-in., 40M-byte Titan and Spartan drives; the buffer lets you queue up extra data and perform 1:1-interleave reads and writes.

Quantum has gone further by adding a 60k-byte cache to its Q200 family of half- and full-height 5¼-in. drives. The drives range in capacity from 53M to 160M bytes. The caching scheme employs a simple algorithm that reads ahead a programmable amount of sequential data. (Some types of software regularly access sequential data.)

The Quantum cache can keep as many as 12 segments of read data in memory at once. If you program a smaller number of segments, you can buffer more data

Text continued on pg 142

TABLE 1—3½- AND 5¼-IN. WINCHESTER DISK DRIVES WITH EMBEDDED SCSI

	GENERAL CHARACTERISTICS				HEAD/DISK-ASSEMBLY CHARACTERISTICS					
MANUFACTURER	MODEL	PRICE (QUANTITY)	CAPACITY (M BYTES) F=FORMATTED U=UNFORMATTED	SIZE (IN.) F=FULL HEIGHT H=HALF HEIGHT	NUMBER OF HEADS READ-WRITE/SERVO	NUMBER OF PLATTERS	POWER DISSIPATION (W)	ACTUATOR TYPE VCM=VOICE COIL	AVERAGE SEEK TIME (mSEC)	DISK DATA RATE (M BPS)
ATASI CORP	TM 2085	$1220 (10)	85.3 U 74.02 F	5¼ F	8/1	5	35	LINEAR VCM	25	5
	TM 2128	$1395 (10)	128 U 115.15 F	5¼ F	8/1	5	35	LINEAR VCM	25	7.5
	TM 2170	$1750 (10)	170.6 U 154.14 F	5¼ F	8/1	5	35	LINEAR VCM	25	7.5
CENTURY DATA INC, CAST DIV	10203	$700 (1000)	65 F	5¼ H	3/1	2	30	LINEAR VCM	28	10
	10304	$950 (1000)	87 F	5¼ H	4/1	3	30	LINEAR VCM	28	10
	10305	$1150 (1000)	110 F	5¼ H	5/1	3	30	LINEAR VCM	28	10
	14405	$1000 (1000)	143 F	5¼ H	5/1	3	34	LINEAR VCM	NS	10
	14406	$1190 (1000)	170 F	5¼ H	7/1	4	34	LINEAR VCM	NS	10
CONNER PERIPHERALS	CP340	$700 (1000)	50 U 40 F	3½	4	2	7	ROTARY VCM	29	NS
	CP3100	$995 (1000)	120 U 100 F	3½	8	4	7	ROTARY VCM	25	NS
CONTROL DATA CORP	WREN III 94211-89	$995 (5000)	89 F	5¼ H	5/1	3	22	ROTARY VCM	18.5	10
	WREN III 94161-155	$1295 (5000)	160 F	5¼ F	9/1	5	21	ROTARY VCM	18.5	10
	WREN IV 94171-XXX	$1595 (5000)	300 F	5¼ F	9/1	5	30	ROTARY VCM	16.5	10
FUJITSU AMERICA INC	M2244S	$1400 (100)	86 U	5¼ F	5/1	3	29.6	ROTARY VCM	25	10
	M2245S	$1530 (100)	120 U	5¼ F	7/1	5	29.6	ROTARY VCM	25	10
	M2246S	$1595 (100)	172 U	5¼ F	10/1	6	29.6	ROTARY VCM	25	10
	M2249S	$3150 (100)	389 U	5¼ F	15/1	8	34	ROTARY VCM	18	10
HITACHI AMERICA	DK522C-10	$2130 (100)	87.5 F	5¼ H	6/1	4	22	ROTARY VCM	25	NS
	DK512C-17	$2830 (100)	146.7 F	5¼ F	10/1	6	45	ROTARY VCM	23	NS
LAPINE TECHNOLOGY INC	TITAN LT400	$575 (1000)	42.8 F	3½	4	2	15	STEPPER	40	10
	SPARTAN LT4000	$550 (1000)	42.8 F	3½	4	2	15	STEPPER	35	10
MAXTOR CORP	LXT-170	<$1100 (1000)	170 U	3½	9/1	5	20	ROTARY VCM	20	NS
	XT-3170	$1185 (1000)	146.6 F	5¼ F	9/1	5	30	ROTARY VCM	30	7.5
	XT-3280	$1500 (1000)	244.4 F	5¼ F	15/1	8	30	ROTARY VCM	30	7.5
	XT-3380	$1995 (1000)	319.6 F	5¼ F	15/1	8	30	ROTARY VCM	27	10
	XT-41705	$1185 (1000)	149.2 F	5¼ F	7/1	4	30	ROTARY VCM	18	10
	XT-42805	$1500 (1000)	234.4 F	5¼ F	11/1	6	30	ROTARY VCM	18	10

*NS=NOT SPECIFIED

SCSI CCS OPTIONAL COMMANDS BY OPCODE:

01= REZERO UNIT
07= REASSIGN BLOCKS
0B= SEEK
15= MODE SELECT
18= COPY
1A= MODE SENSE
1B= START/STOP UNIT
1C= RECEIVE DIAGNOSTIC RESULTS

OPERATING ENVIRONMENT			DATA INTEGRITY		SCSI CHARACTERISTICS							
OPERATING TEMPERATURE	OPERATING HUMIDITY	MTBF (HOURS)	SOFT-ERROR RATE (BITS)	HARD-ERROR RATE (BITS)	SCSI CCS MANDATORY	DISCONNECT/ RECONNECT	CCS OPTIONAL COMMANDS SUPPORTED BY OPCODE	SCSI RATE (M BYTES/SEC) S=SYNC A=ASYNC	COMMAND-DECODE TIME	BUFFER SIZE (BYTES)	PARITY CHECK AT BUFFER	PARITY CHECK AT INTERFACE
4-50°C	10-80%	20,000	1 IN 10^{10}	1 IN 10^{12}	Y	N	01, 07, 15, 18, 1A, 1B, 2F, 3B, 3C	1.25 A	NS*	NS	NS	NS
4-50°C	10-80%	20,000	1 IN 10^{10}	1 IN 10^{12}	Y	N	01, 07, 15, 18, 1A, 1B, 2F, 3B, 3C	1.25 A	NS	NS	NS	NS
4-50°C	10-80%	20,000	1 IN 10^{10}	1 IN 10^{12}	Y	N	01, 07, 15, 18, 1A, 1B, 2F, 3B, 3C	1.25 A	NS	NS	NS	NS
10-46°C	8-80%	15,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	NS	1.5 A	NS	NS	NS	NS
10-46°C	8-80%	15,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	NS	1.5 A	NS	NS	NS	NS
10-46°C	8-80%	15,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	NS	1.5 A	NS	NS	NS	NS
10-46°C	8-80%	15,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	NS	1.5 A	NS	NS	NS	NS
10-46°C	8-80%	15,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	NS	1.5 A	NS	NS	NS	NS
5-55°C	8-80%	20,000	NS	NS	Y	Y	01, 07, 0B, 1A, 2B, 3B, 3C	2.0 A	1 mSEC	1k	Y	Y
5-55°C	8-80%	20,000	NS	NS	Y	Y	01, 07, 0B, 1A, 2B, 3B, 3C	2.0 A	1 mSEC	16k	Y	Y
10-50°C	8-80%	30,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 0B, 1B, 1C, 2B	1.25 A	NS	32k	Y	Y
10-50°C	8-85%	30,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 0B, 1B, 1C, 2B	1.5 A	NS	32k	Y	Y
10-50°C	8-90%	30,000	NS	1 IN 10^{14}	Y	Y	01, 0B, 1B, 1C, 2B, 2F	1.5 A 3.0 S	NS	32k	Y	Y
41-113°C	20-80%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2B, 2F, 33, 37, 3B, 3C	1.5 A 2.5 S	600 μSEC	16k	Y	Y
41-113°C	20-80%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2B, 2F, 33, 37, 3B, 3C	1.5 A 2.5 S	600 μSEC	16k	Y	Y
41-113°C	20-80%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2B, 2F, 33, 37, 3B, 3C	1.5 A 2.5 S	600 μSEC	16k	Y	Y
41-113°C	20-80%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2B, 2F, 33, 37, 3B, 3C	1.5 A 2.5 S	600 μSEC	16k	Y	Y
5-45°C	8-80%	30,000	1 IN 10^{10}	1 IN 10^{14}	Y	Y	01, 07, 0B, 15, 1A, 1B, 1C, 2B, 2E, 2F, 37, 3B, 3C	1.5 A	1.5 mSEC	1k	Y	Y
5-45°C	8-80%	20,000	1 IN 10^{10}	1 IN 10^{14}	Y	Y	01, 07, 0B, 15, 1A, 1B, 1C, 2B, 2E, 2F, 37, 3B, 3C	1.5 A	1.5 mSEC	1k	Y	Y
5-55°C	10-90%	28,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 2B, 2E, 2F, 37, 3B, 3C	1.2 A	NS	8k	N	N
5-55°C	8-90%	28,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 2B, 2E, 2F, 37, 3B, 3C	1.2 A	NS	8k	N	N
10-45°C	8-80%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 2B, 2E, 2F, 3B, 3C	1.5 A	850 μSEC	NS	N	Y
10-45°C	8-80%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 2B, 2E, 2F, 3B, 3C	1.5 A	850 μSEC	8k	N	Y
10-45°C	8-80%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 2B, 2E, 2F, 3B, 3C	1.5 A	850 μSEC	8k	N	Y
10-45°C	8-80%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 2B, 2E, 2F, 3B, 3C	1.5 A	850 μSEC	32k	N	Y
10-45°C	8-80%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 2B, 2E, 2F, 3B, 3C	1.5 A	850 μSEC	8k	N	Y
10-45°C	8-80%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 2B, 2E, 2F, 3B, 3C	1.5 A	850 μSEC	8k	N	Y

1E= PREVENT/ALLOW MEDIUM REMOVAL
2B= SEEK EXTENDED
2E= WRITE AND VERIFY
2F= VERIFY
30= SEARCH DATA HIGH
31= SEARCH DATA EQUAL
32= SEARCH DATA LOW
33= SET LIMITS
37= READ DEFECT DATA
39= COMPARE
3A= COPY AND VERIFY
3B= WRITE BUFFER
3C= READ BUFFER

TABLE 1—3½- AND 5¼-IN. WINCHESTER DISK DRIVES WITH EMBEDDED SCSI *(Continued)*

	GENERAL CHARACTERISTICS				HEAD/DISK-ASSEMBLY CHARACTERISTICS					
MANUFACTURER	MODEL	PRICE (QUANTITY)	CAPACITY (M BYTES) F=FORMATTED U=UNFORMATTED	SIZE (IN.) F=FULL HEIGHT H=HALF HEIGHT	NUMBER OF HEADS READ-WRITE/SERVO	NUMBER OF PLATTERS	POWER DISSIPATION (W)	ACTUATOR TYPE VCM=VOICE COIL	AVERAGE SEEK TIME (mSEC)	DISK DATA RATE (M BPS)
MAXTOR *(Continued)*	XT-43805	$1995 (1000)	319.6 F	5¼ F	15/1	8	30	ROTARY VCM	18	10
	XT-83805	$1900 (1000)	320.8 F	5¼ F	8/1	5	30	ROTARY VCM	16	15
	XT-87605	$3600 (1000)	601.6 F	5¼ F	15/1	8	30	ROTARY VCM	18	15
MICROPOLIS CORP	1373	$1350 (1000)	85 U 76 F	5¼ F	4/1	3	35	ROTARY VCM	23	10
	1373A	$1450 (1000)	106 U 95 F	5¼ F	5/1	3	35	ROTARY VCM	23	10
	1374	$1550 (1000)	128 U 115 F	5¼ F	6/1	4	35	ROTARY VCM	23	10
	1374A	$1550 (1000)	149 U 134 F	5¼ F	7/1	4	35	ROTARY VCM	23	10
	1375	$1550 (1000)	170 U 153 F	5¼ F	8/1	5	35	ROTARY VCM	23	10
	1578-15	$1995 (1000)	382 U 344 F	5¼ F	15/1	8	35	ROTARY VCM	18	10
MICROSCIENCE INTERNATIONAL CORP	HH-1080	$850 (1000)	89 U	5¼ H	5/1	3	15.5	LINEAR VCM	28	10
MINISCRIBE CORP	8425S	$434 (500)	25.5 U 21.3 F	3½	4	2	12.5	STEPPER	68	10
NEWBURY DATA INC	NDR 3170S	$1500 (1000)	147 F	5¼ F	9/1	5	25	ROTARY VCM	28	7.5
	NDR 3280S	$1800 (1000)	244 F	5¼ F	15/1	8	25	ROTARY VCM	28	7.5
	NDR 3380S	$1900 (1000)	320 F	5¼ F	15/1	8	25	ROTARY VCM	28	10
PRIAM CORP	717	$1980 (100)	178.6 U	5¼ F	7/1	4	38	LINEAR VCM	20	10
	728	$2405 (100)	280.7 U	5¼ F	11/1	6	38	LINEAR VCM	20	10
	738	$2830 (100)	382.7 U	5¼ F	15/1	8	38	LINEAR VCM	20	10
QUANTUM CORP	Q250	$750 (1000)	53 F	5¼ H	4	2	24	ROTARY VCM	26	10
	Q280	$950 (1000)	80 F	5¼ H	6	3	24	ROTARY VCM	26	10
	Q160	$1395 (1000)	160 F	5¼ F	12	6	26	ROTARY VCM	26	10
RODIME INC	RO 652A	$895 (1)	21.3 F	3½	4	2	12.5	STEPPER	85	7.5
	RO 3057S	$1195 (1)	45.3 F	3½	5/1	3	13	ROTARY VCM	28	7.5
	RO 3070S	$1395 (1)	58 F	3½	5/1	3	13	ROTARY VCM	28	7.5
	RO 3085S	$1495 (1)	69.6 F	3½	7/1	4	13	ROTARY VCM	28	7.5
	RO 5075S	$1395 (1)	64.3 F	5¼ H	3/1	2	18	ROTARY VCM	28	7.5
	RO 5125S	$1595 (1)	107 F	5¼ H	5/1	3	18	ROTARY VCM	28	7.5
	RO 5180S	$1795 (1)	150 F	5¼ H	7/1	4	18	ROTARY VCM	28	7.5

*NS=NOT SPECIFIED

SCSI CCS OPTIONAL COMMANDS BY OPCODE:

01= REZERO UNIT
07= REASSIGN BLOCKS
0B= SEEK
15= MODE SELECT
18= COPY
1A= MODE SENSE
1B= START/STOP UNIT
1C= RECEIVE DIAGNOSTIC RESULTS

OPERATING ENVIRONMENT			DATA INTEGRITY		SCSI CHARACTERISTICS								
OPERATING TEMPERATURE	OPERATING HUMIDITY	MTBF (HOURS)	SOFT-ERROR RATE (BITS)	HARD-ERROR RATE (BITS)	SCSI CCS MANDATORY	DISCONNECT/ RECONNECT	CCS OPTIONAL COMMANDS SUPPORTED BY OPCODE	SCSI RATE (M BYTES/SEC) S=SYNC A=ASYNC	COMMAND-DECODE TIME	BUFFER SIZE (BYTES)	PARITY CHECK AT BUFFER	PARITY CHECK AT INTERFACE
10-45°C	8-80%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 2B, 2E, 2F, 3B, 3C	1.5 A	850 μSEC	32k	N	Y
10-45°C	8-80%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 2B, 2E, 2F, 3B, 3C	1.5 A	850 μSEC	32k	N	Y
10-45°C	8-80%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 2B, 2E, 2F, 3B, 3C	1.5 A	850 μSEC	32k	N	Y
10-50°C	10-90%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 1B, 1C, 2B, 2E, 2F, 37, 3B, 3C	1.25 A	1.5 mSEC	14k	Y	Y
10-50°C	10-90%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 1B, 1C, 2B, 2E, 2F, 37, 3B, 3C	1.25 A	1.5 mSEC	14k	Y	Y
10-50°C	10-90%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 1B, 1C, 2B, 2E, 2F, 37, 3B, 3C	1.25 A	1.5 mSEC	14k	Y	Y
10-50°C	10-90%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 1B, 1C, 2B, 2E, 2F, 37, 3B, 3C	1.25 A	1.5 mSEC	14k	Y	Y
10-50°C	10-90%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 1B, 1C, 2B, 2E, 2F, 37, 3B, 3C	1.25 A	1.5 mSEC	14k	Y	Y
10-50°C	10-90%	30,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 1B, 1C, 2B, 2E, 2F, 37, 3B, 3C	1.25 A	1.5 mSEC	16k	Y	Y
50-122°F	8-80%	30,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	NS	1.5 A	950 μSEC	32k	N	Y
4-50°C	8-80%	20,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 2B, 2E, 2F, 37, 3B, 3C	1.0 A	NS	1k	Y	Y
10-45°C	8-80%	20,000	NS	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2E, 2F, 37, 3B, 3C	1.5 A	NS	32k	NS	NS
10-45°C	8-80%	20,000	NS	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2E, 2F, 37, 3B, 3C	1.5 A	NS	32k	NS	NS
10-45°C	8-80%	20,000	NS	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B 2E, 2F, 37, 3B, 3C	1.5 A	NS	32k	NS	NS
10-50°C	8-80%	20,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 1C, 2B, 2E, 2F, 30, 31, 32, 33, 37, 3B, 3C	1.5 A	2.5 mSEC	64k	Y	Y
10-50°C	8-80%	20,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 1C, 2B, 2E, 2F, 30, 31, 32, 33, 37, 3B, 3C	1.5 A	2.5 mSEC	64k	Y	Y
10-50°C	8-80%	20,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 1C, 2B, 2E, 2F, 30, 31, 32, 33, 37, 3B, 3C	1.5 A	2.5 mSEC	64k	Y	Y
4-50°C	8-85%	25,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	07, 0B, 15, 18, 1A, 1B, 1C, 2F, 37, 3B, 3C	1.25 A	3 mSEC	64k	Y	Y
4-50°C	8-85%	25,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	07, 0B, 15, 18, 1A, 1B, 1C, 2F, 37, 3B, 3C	1.25 A	3 mSEC	64k	Y	Y
4-50°C	8-85%	25,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	07, 0B, 15, 18, 1A, 1B, 1C, 2F, 37, 3B, 3C	1.25 A	3 mSEC	64k	Y	Y
10-50°C	10-85%	12,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2F, 37, 3B, 3C	1.0 A	NS	4k	Y	Y
10-50°C	10-85%	20,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2F, 37, 3B, 3C	1.0 A	NS	4k	Y	Y
10-50°C	10-85%	20,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2F, 37, 3B, 3C	1.0 A	NS	4k	Y	Y
10-50°C	10-85%	20,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2F, 37, 3B, 3C	1.0 A	NS	4k	Y	Y
10-50°C	10-85%	20,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2F, 37, 3B, 3C	1.0 A	NS	4k	Y	Y
10-50°C	10-85%	20,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2F, 37, 3B, 3C	1.0 A	NS	4k	Y	Y
10-50°C	10-85%	20,000	10 IN 10^{11}	10 IN 10^{13}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2F, 37, 3B, 3C	1.0 A	NS	4k	Y	Y

1E= PREVENT/ALLOW MEDIUM REMOVAL
2B= SEEK EXTENDED
2E= WRITE AND VERIFY
2F= VERIFY

30= SEARCH DATA HIGH
31= SEARCH DATA EQUAL
32= SEARCH DATA LOW
33= SET LIMITS

37= READ DEFECT DATA
39= COMPARE

3A= COPY AND VERIFY
3B= WRITE BUFFER
3C= READ BUFFER

TABLE 1—3½- AND 5¼-IN. WINCHESTER DISK DRIVES WITH EMBEDDED SCSI *(Continued)*

	GENERAL CHARACTERISTICS				HEAD/DISK-ASSEMBLY CHARACTERISTICS					
MANUFACTURER	MODEL	PRICE (QUANTITY)	CAPACITY (M BYTES) F=FORMATTED U=UNFORMATTED	SIZE (IN.) F=FULL HEIGHT H=HALF HEIGHT	NUMBER OF HEADS READ-WRITE/SERVO	NUMBER OF PLATTERS	POWER DISSIPATION (W)	ACTUATOR TYPE VCM=VOICE COIL	AVERAGE SEEK TIME (mSEC)	DISK DATA RATE (M BPS)
SEAGATE TECHNOLOGY	ST138N	$600 (500)	32.3 F	3½	4	2	11	STEPPER	30	7.5
	ST157N	$695 (500)	48.6 F	3½	6	3	11	STEPPER	30	7.5
	ST225N	$410 (500)	21.4 F	5¼ H	4	2	16.8	STEPPER	65	5
	ST251N	$705 (500)	43.1 F	5¼ H	4	2	13	STEPPER	40	7.5
	ST277N	$750 (500)	64.9 F	5¼ H	6	3	13	STEPPER	40	7.5
	ST4077N	$845 (500)	67.6 F	5¼ F	5/1	3	25	LINEAR VCM	28	7.5
	ST4096N	$1310 (500)	83.9 F	5¼ F	4/1	3	25	LINEAR VCM	17	10
	ST4144N	$1220 (500)	122.1 F	5¼ F	9/1	5	25	LINEAR VCM	28	7.5
	ST4192N	$1625 (500)	168.5 F	5¼ F	8/1	5	25	LINEAR VCM	17	10
SIEMENS INFORMATION SYSTEMS INC	2200	$2900 (50)	174.3 F	5¼ F	8/1	5	30	ROTARY VCM	25	10
	2300	$3900 (50)	261.4 F	5¼ F	12/1	7	30	ROTARY VCM	25	10
TOSHIBA AMERICA INC	MK-153FB	$1315	86 U 76 F	5¼ F	5/1	4	30	ROTARY VCM	23	10
	MK-154FB	$1535	121 U 106.4 F	5¼ F	7/1	5	30	ROTARY VCM	23	10
	MK-156FB	$1755	172.9 U 152.1 F	5¼ F	10/1	6	30	ROTARY VCM	23	10

*NS=NOT SPECIFIED

SCSI CCS OPTIONAL COMMANDS BY OPCODE:

01= REZERO UNIT
07= REASSIGN BLOCKS
0B= SEEK
15= MODE SELECT
18= COPY
1A= MODE SENSE
1B= START/STOP UNIT
1C= RECEIVE DIAGNOSTIC RESULTS

per segment. On cache hits, the scheme reduces access time to less than 10 msec for drives with 24-msec seek times, and it eliminates rotational latency. The scheme does add 400 μsec of overhead to cache misses. Quantum product manager Tony Lo believes all vendors will offer some form of caching within three years. Micropolis also plans to add caching to its SCSI products later this year.

At present, the data-transfer-rate spec does little to distinguish the performance of a SCSI drive from that of an ESDI (Enhanced Small Device Interface) drive or the performance of one SCSI drive from another. The SCSI document specifies maximum transfer rates of 1.5M bytes/sec for asynchronous operation and 4M bytes/sec for synchronous transfers. Most drives currently operate asynchronously at 1.25M or 1.5M bytes/sec. Host adapters and ICs that perform synchronous transfers are just beginning to emerge.

Most drives currently operate at 10M bps in the read channel; 1.25M-byte/sec transfers can keep pace with this read-channel data rate. Drives with buffers and 1.5M-byte/sec rates can burst data across the interface at marginally faster rates, thus clearing the bus sooner. ESDI drives also operate at 10M bps, but that spec may soon be modified to increase the maximum rate to 15M or even 24M bps. In fact, a few ESDI drives already specify 15M-bps data rates. And an embedded-SCSI drive, the 20M-byte 8425S from Miniscribe, already uses a custom voltage-controlled oscillator and address mark/detection scheme that will support a 24M-bps read channel.

As manufacturers increase density, increase the speed of the read channel, and increase the buffer size in their SCSI drives, however, drive transfer rate will become a more important issue. Fujitsu and Control Data have already added synchronous capabilities to their SCSI products. Fujitsu's M2200 drives operate at synchronous speeds of 2.5M bytes/sec, and Control

OPERATING ENVIRONMENT			DATA INTEGRITY		SCSI CHARACTERISTICS								
OPERATING TEMPERATURE	OPERATING HUMIDITY	MTBF (HOURS)	SOFT-ERROR RATE (BITS)	HARD-ERROR RATE (BITS)	SCSI CCS MANDATORY	DISCONNECT/ RECONNECT	CCS OPTIONAL COMMANDS SUPPORTED BY OPCODE	SCSI RATE (M BYTES/SEC) S=SYNC A=ASYNC	COMMAND-DECODE TIME	BUFFER SIZE (BYTES)	PARITY CHECK AT BUFFER	PARITY CHECK AT INTERFACE
10-45°C	NS	NS	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2B, 2F, 37, 3B, 3C	1.5 A	2 mSEC	2k	N	Y
10-45°C	NS	NS	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2B, 2F, 37, 3B, 3C	1.5 A	2 mSEC	2k	N	Y
10-45°C	8-80%	20,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2B, 2F, 37, 3B, 3C	1.5 A	2 mSEC	1k	N	Y
10-45°C	8-80%	20,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2B, 2F, 37, 3B, 3C	1.5 A	2 mSEC	8k	N	Y
10-45°C	8-80%	20,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2B, 2F, 37, 3B, 3C	1.5 A	2 mSEC	8k	N	Y
10-45°C	8-80%	20,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2B, 2F, 37, 3B, 3C	1.5 A	2 mSEC	8k	N	Y
10-45°C	8-80%	20,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2B, 2F, 37, 3B, 3C	1.5 A	2 mSEC	8k	N	Y
10-45°C	8-80%	20,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2B, 2F, 37, 3B, 3C	1.5 A	2 mSEC	8k	N	Y
10-45°C	8-80%	20,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2B, 2F, 37, 3B, 3C	1.5 A	2 mSEC	8k	N	Y
10-45°C	20-80%	15,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 1C, 2B, 2F, 37	1.5 A	470 μSEC	32k	N	Y
10-45°C	20-80%	15,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 1C, 2B, 2F, 37	1.5 A	470 μSEC	32k	N	Y
5-50°C	20-80%	30,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2E, 2F, 30, 31, 32, 33, 37, 3B, 3C	1.25 A	1 mSEC	32k	N	Y
5-50°C	20-80%	30,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2E, 2F, 30, 31, 32, 33, 37, 3B, 3C	1.25 A	1 mSEC	32k	N	Y
5-50°C	20-80%	30,000	1 IN 10^{10}	1 IN 10^{12}	Y	Y	01, 07, 0B, 15, 1A, 1B, 2E, 2F, 30, 31, 32, 33, 37, 3B, 3C	1.25 A	1 mSEC	32k	N	Y

1E= PREVENT/ALLOW MEDIUM REMOVAL
2B= SEEK EXTENDED
2E= WRITE AND VERIFY
2F= VERIFY
30= SEARCH DATA HIGH
31= SEARCH DATA EQUAL
32= SEARCH DATA LOW
33= SET LIMITS
37= READ DEFECT DATA
39= COMPARE
3A= COPY AND VERIFY
3B= WRITE BUFFER
3C= READ BUFFER

Data's 300M-byte Wren IV runs at 3M bytes/sec. Micropolis plans to release an enhanced version of its embedded SCSI controller in the third quarter of this year. The Micropolis 1300- and 1500-family products, which reach 322M bytes, will be able to operate at 4M bytes/sec with the new controller, and their command-decode time will drop to 750 μsec.

Furthermore, an ANSI committee is working to extend the data-transfer rate in the SCSI specification. The revised interface, SCSI 2, will widen the bus from 8 to 16 bits, or increase the bus speed, or both. You can expect SCSI 2 to offer 10M-byte/sec bus-transfer rates. Although manufacturers may not be able to make their SCSI devices that fast, large buffers on the controller boards will enable the devices to get on and off the bus quickly. In addition, some vendors of 5¼-in. SCSI drives are expected this year to introduce products containing multiple drives that operate in parallel with synchronized spindles.

For some designers, compatibility among SCSI products may be even more important than the products' individual performance. The first generation of SCSI ICs had peculiarities that caused hardware-compatibility problems between two products that contained chips from different vendors. Most such problems have disappeared, but other compatibility problems persist. By incorporating certain mandatory commands, the SCSI Common Command Set (CCS) provides a base level of compatibility while still including optional and vendor-unique commands.

Drive manufacturers use these optional and vendor-unique commands in their SCSI drives to provide product differentiation. To make your SCSI system compatible with drives from many different vendors, therefore, you have to implement your operating-system driver carefully. You should restrict the optional commands you implement in your operating-system driver to those that you really need, or those

Command-decode time and arbitration delays contribute to the overhead inherent in SCSI systems, but the SCSI architecture may still boost system performance.

Interpreting SCSI commands in 470 μsec, *the Megafile products from Siemens reduce SCSI overhead to an insignificant level. The drives have formatted capacities of as much as 261M bytes.*

that are widely supported by drive vendors.

For example, virtually every manufacturer has implemented mode-sense and mode-select commands in its embedded controllers. These two commands allow you to program drive characteristics such as sector size and defect-management scheme. You use these commands differently in drives from different vendors, but you can develop a driver that can adjust to several drive vendors' different SCSI implementations. If you don't intend to use the mode-sense and mode-select capabilities, however, be sure to choose a drive whose default features suit you.

Some drive manufacturers provide other methods of setting drive characteristics. For example, Priam's 700 Series full-height, 5¼-in. drives, whose unformatted capacities range from 179M to 383M bytes, provide DIP switches that you can use to select sector size. You can also use the mode-sense and mode-select commands. Atasi provides a similar method of selecting sector size on its TM 2000 family of drives, which offer 74M- to 154M-byte capacities.

The embedded-SCSI-drive vendors have all attempted to standardize the SCSI implementation within their particular product families, so once you've selected a vendor, you can typically use any of that vendor's drives with your operating-system driver. In fact, most vendors use identical interfaces even for products based on different HDAs.

You can also choose to buy drives with command implementations unique to your company. By doing so, you can stifle the efforts of third-party suppliers of products compatible with your product. To serve customers that desire unique features and customers that want multiple sources for compatible products, SCSI-drive manufacturers are determined to be flexible. In fact, almost all drive vendors will customize their SCSI implementations for customers that order in sufficient quantities to qualify for normal direct sales. Before the advent of embedded controllers, the controller houses received most of the requests for customization.

Surprisingly, it's Seagate, which has the highest sales volume for Winchester drives, that seems the best prepared to handle customization. On its new SCSI products, Seagate stores the SCSI firmware, along with other drive-personality data, on an unused track of the disk. The controller reads the firmware into RAM on power-up. Using this scheme, Seagate can customize the drive just before packing it for shipment. In addition, sophisticated customers can modify the SCSI firmware in the field.

Drive personality hides behind SCSI

Behind the SCSI interfaces, other aspects of controllers from different manufacturers are even less compatible than SCSI itself. For example, drive format, bit and track density, defect-management scheme, head/media and read-channel error rate, and ECC (Error Correction Code) are different from manufacturer to manufacturer. These factors affect only the operation behind the interface and are transparent to the system, but some of them may have an effect on your drive selection.

Consider defect management, for example. Typically, the controller allocates one to three spare sectors per track. When the controller detects a bad sector, it maps the sector into one of the spares. If the spares have been used, the drive must seek to an outer track to relocate the sector. Most controllers allow you to program the number of spare sectors they allocate. The more spares you allocate, the more data capacity you lose. If the controller has to map sectors to an outer track, however, the extra electromechanical seeks degrade the drive's performance.

Cylindrical zoning saves capacity

A few drive manufacturers offer a defect-management scheme called cylindrical zoning. Quantum offered this scheme first on its SCSI drives. Maxtor now offers it as well, and Micropolis and Priam will do so later this year. The cylindrical zoning scheme allocates spare sectors on a cylinder basis rather than on a track basis.

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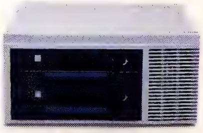

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CIRCLE NO 154

Data integrity involves a drive's head/media interface, defect-management scheme, and ECC implementation.

Relocating a sector requires a head swap, but the swap occurs in virtually zero time. By keeping spares on a cylinder basis, the controller allocates fewer total spares, yet is less likely to need to seek to an outer track when it must relocate bad sectors.

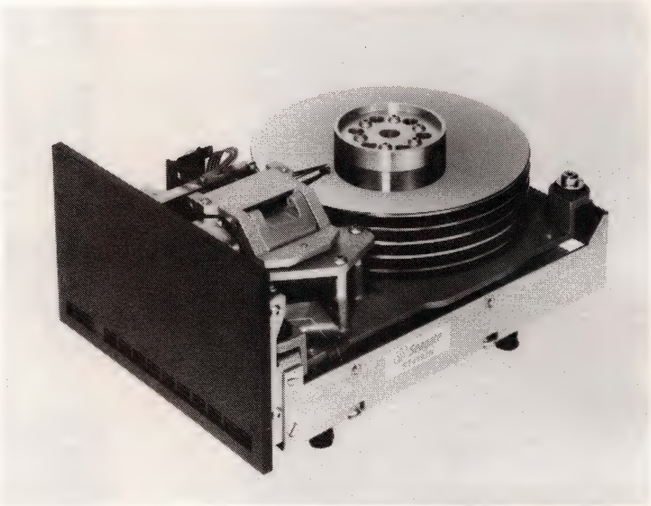
Both defect-management and ECC functions present new problems for drive vendors. In the past, a few specialized controller houses handled these issues, but vendors of embedded-controller drives must now handle them.

Regardless of where they are implemented, these functions affect data integrity, so they'll be important factors in your system implementation. For drives with device-level interfaces, manufacturers simply specify soft- and hard-error rates. Soft errors are errors that are corrected by retries; to correct hard errors, the controller must invoke an ECC. The standard soft- and hard-error rate specs are one bad bit in 10^{10} bits read and one bad bit in 10^{12} bits read, respectively. Many manufacturers still specify error rates this way for embedded-controller drives, but these specs have no meaning at the interface.

ECC schemes employ black magic

To determine whether an embedded-SCSI drive preserves data integrity well enough for your application, you need to investigate the way the controller implements the ECC. Unfortunately, ECCs are something of a black art, and even the drive vendors don't understand very well how they work. Adding to the problem is the fact that no standard specs exist for evaluating an ECC implementation. Both drive and controller houses hire consultants to help implement ECCs. ECC schemes involve storing some data in each sector and using the data with a complex polynomial to correct errors.

Data Systems Technology (Broomfield, CO) develops ECC schemes for a number of drive vendors. Company president Neal Glover agrees that the industry lacks quantifiable specs for error-correction capabilities on drives. Glover advises drive manufacturers to consider a population of drives operating for one year. During the year, he says, you should note how many times any of the drives has an uncorrectable error and how many times an error goes undetected, thereby corrupting the data on a disk. Glover believes such a consideration has more meaning than putting a probability of 1 in 10^{14} on uncorrectable data and 1 in 10^{21} on undetected errors. Drive manufacturers have considered using such specs, and they may even report such specs when speaking to you, but most do not use these specs on their data sheets.



Emphasizing flexibility in its SCSI implementation, *Seagate stores drive firmware on an unused portion of its 160M-byte (formatted) ST4192N drive. The drive reads the SCSI firmware driver into RAM on power-up. This scheme allows the company to customize drives.*

Glover explains that different ECCs are sensitive to different error situations. For example, an ECC known as Firecode will not detect two short error bursts but will correct a single longer burst.

Data Systems Technology has developed what it calls a computer-generated ECC, and many drive vendors are using it. This ECC was originally generated as a 32-bit code capable of handling error bursts four or five bits in length. Disk manufacturers found this length to be the typical length of an error burst on a disk that uses MFM encoding. In RLL-coded data, an error can propagate into four or five more bits, so many drive vendors have converted the length of their computer-generated ECCs to 48 bits.

Computer-generated ECCs become standard

Data Systems Technology has attempted to set industry standards for 32-, 48-, and 56-bit computer-generated ECCs. Glover also points out that the Reed-Solomon scheme is becoming popular. According to Glover, the Reed-Solomon code's strength lies in detecting multiple error bursts. Data Systems Technology also licenses a Reed-Solomon ECC scheme, but Glover believes that his computer-generated codes perform just as well on a single error burst. He also adds that some companies offer Reed-Solomon codes just because their market and customers perceive a need for them.

Optical media, which have hard-error rates as high as

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The Rimfire® 3500 SCSI Host Bus Adapter is for VMEbus users who want it all. Performance. Versatility. And low price.

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It's for those who want a simple command queuing software interface, free of timing restrictions. For those who want to conserve bus bandwidth with a 30 Mbyte/sec VMEbus burst rate.

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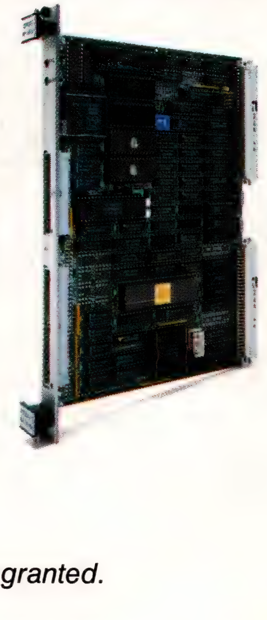

The Ciprico Rimfire 3500 Host Bus Adapter enables VMEbus system developers to take full advantage of any high performance SCSI device. Software support for the board includes drivers for the System V and BSD 4.2 versions of the UNIX operating system.

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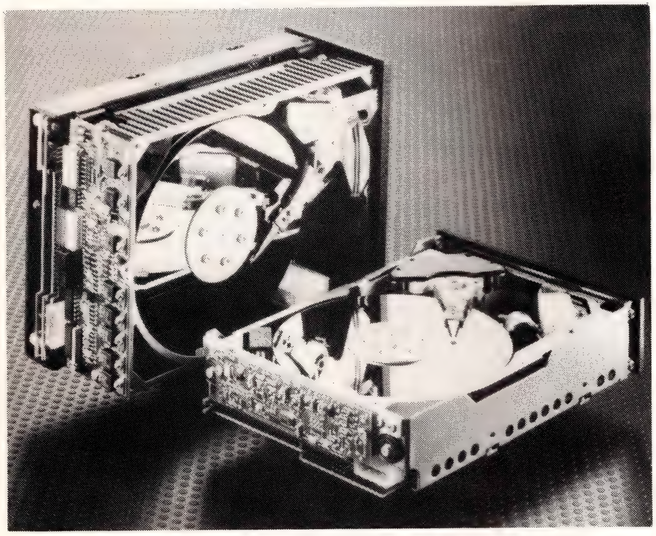
CIRCLE NO 118

Because SCSI isolates a drive's read channel from the interface, disk-test equipment for SCSI drives can't easily provide phase-margin testing.



A 16.5-msec average seek time and a 3M-byte/sec synchronous SCSI *data-transfer rate make Control Data's Wren IV drive suitable for use in high-end SCSI systems. The drive features a 300M-byte formatted capacity, and it implements a 48-bit ECC scheme.*

1 in 10^4, require Reed-Solomon ECCs, Glover believes, but he thinks the codes can be overkill for magnetic media, which have a hard-error rate of 1 in 10^{12}. Reed-Solomon codes use more of a disk's capacity than do the computer-generated codes. Glover also claims that corrupted header fields and data-sync marks may cause more trouble in today's embedded controllers than corrupted data does. The manufacturers take precautions to protect the data fields but leave the headers and sync marks unprotected. Glover believes that fault tolerance should be designed into those fields.

A few of the embedded-SCSI-drive vendors specify the number of bits that can be corrected and detected in a single sector. For example, Quantum drives employ a 96-bit Reed-Solomon code. The code can detect as many as three bursts of 17 bits each and can correct one burst of 17 bits. Most drive manufacturers don't put these specs on their data sheets; however, according to Glover, the drives that use his computer-generated codes typically can detect one burst of 22 bits and correct one burst of 11 bits.

You'll find test issues equally confusing when you're evaluating Winchesters with embedded controllers. When 5¼-in. Winchesters were first introduced, system manufacturers had to perform rigorous evaluation tests on them, because these early 5¼-in. drives were fairly unreliable.

Although modern 5¼-in. disk drives are more reliable, system designers seem unwilling to stop performing the detailed evaluation tests, which include margin testing and windowing in the read-channel electronics. Performing these tests in embedded-SCSI drives is more difficult, however, because in these drives the SCSI connector stands between the test equipment and the drive electronics. You can't buy off-the-shelf test equipment for embedded-SCSI drives as you can for drives with device-level interfaces. Test equipment for embedded-SCSI Winchesters does exist, however (see **box,** "SCSI test and development").

Drive vendors have approached the test issue in many different ways. Some vendors, such as Lapine, provide connections to the read channel. Such connections, however, are not standard from vendor to vendor, and it seems unlikely that any standardization will occur. Maxtor and Micropolis essentially allow you to tap into an ESDI interface, although you do so through test points instead of through a standard ESDI connector. Priam places the read channel and the servo control on boards separate from the controller, so that testing an ESDI version will test the same read-channel electronics that the SCSI product uses. Seagate has added firmware and circuitry that allow you to control some margin testing from the SCSI port.

Drive vendors with experience in making larger Winchester drives unanimously state that such detailed testing of 5¼-in. drives is no longer necessary. These vendors claim that such testing was never needed for 8-, 9-, and 14-in. products. Furthermore, they believe that 5¼-in. drives have overcome their rocky start and no longer need the stringent testing, both because the smaller head and media are more reliable and, in embedded-SCSI products, because the controller is on the drive.

Head/media quality improves in HDAs

Once you've evaluated your interface needs, you should give some thought to the drives' head/disk assemblies. Although HDAs have not changed drastically, they have definitely improved. Consider media, for example. Most newly designed drives employ plated thin-film media and thin-film heads. Some of the high-end drives use sputtered media, and more manufacturers will probably switch to sputtered media. A few companies, such as Fujitsu and Atasi, continue to use an oxide medium, considering it a safer choice. Note, however, that the oxide medium is more prone to head crashes, and the heads can't fly as close to it as they can to plated-media surfaces.

Maxtor pioneered the in-hub spindle motor in its first

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ADP-48	SCSI to SMD (10, 15, 20 or 24 MHz) Disk Controller
ADP-53	SCSI to ½" PERTEC Tape Controller
ADP-55	SCSI to QIC-36 Tape Controller
ADP-60	SCSI to Dataproducts Printer Interface (Long Line)
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Drive manufacturers have improved HDAs to the point where stepper-motor actuators achieve seek times of <30 msec; VCM actuators will soon reach 15 msec.

product, and now several other vendors have adopted the technology. Priam and Fujitsu still use external motors in their 8-platter drives. Both these companies cite heat problems in the hub as the reason, but other companies are shipping the in-hub spindle-motor products with no trouble.

In 3½-in. drives, where half-height is the standard height, companies have begun to move to the in-hub motor also. Rodime and Conner Peripherals have been shipping 3½-in. units with in-hub motors, and Maxtor's 3½-in. entry will employ the technology as well. According to Maxtor, the motor for the smaller product required a 75% size reduction over the motors in its 5¼-in. products.

In the area of actuators and actuator motors, manufacturers have also made advancements. Seagate and Lapine both have stepper-motor-based drives that feature average seek times in the 30-msec range. The stepper-motor drives, however, can't achieve the track densities found in drives with voice-coil motors (VCMs).

Most drive manufacturers use rotary actuators in

SCSI test and development

Manufacturers that previously specialized in Winchester-drive test equipment for non-SCSI drives are struggling to provide test equipment for embedded-SCSI drives, because these drives provide no access to the read-channel electronics. However, some companies that haven't previously made Winchester-drive test equipment have come out with test and development equipment that will test embedded-SCSI drives at the interface and aid engineers in developing SCSI host adapters or other SCSI products.

Both Flexstar (Milpitas, CA) and Wilson Laboratories (Orange, CA) have sold test equipment to companies wishing to test and evaluate Winchesters with device-level interfaces. These two companies are finding it difficult to provide a test set for drives with embedded controllers. Because SCSI drives provide no standard window into the read channel, the testers can basically do no more than can a personal computer with a host adapter and a test program.

Flexstar has attempted to solve the problem with its FS6000 test system, but you may consider the solution somewhat cumbersome, because you must use test points and personality modules to connect the tester to the drive. The $12,000 system is controlled by an IBM PC or compatible computer, and it includes probes for testing a drive's read channel. The company sells personality modules that customize the tester for drives from different manufacturers. The system does phase-margin testing and performs a full analysis of the head/disk interface.

Meanwhile, some companies that didn't previously make Winchester-drive test equipment have become aware of the market for SCSI development tools. D-Designs (Palo Alto, CA), for example, offers the DSC-202 SCSI Bus Analyzer-Emulator. The basic analyzer costs $4950, and the emulator adds $1900; together they sell for $6500. An IBM-PC or compatible computer controls the instrument, which has a nonintrusive tracer that can store 8k bytes (or, optionally, 32k bytes) of events. The emulator can function as a target or as an initiator, and the system supports 1.5M-byte/sec SCSI transfers.

Adaptec (Milpitas, CA) has also broadened its product offerings in the SCSI development-tool field. The company's product line includes the SDS-2 development system, the SDS-100 test system, and the SDS-210 SCSI logic analyzer. The products cost $19,500 (which includes an IBM PC/XT), $5500, and $3750, respectively. The SDS-2 provides initiator and target emulation, and it primarily targets SCSI product-development applications.

Adaptec provides menu and program interfaces to the SDS-2. In fact, you can use the SDS-2 to develop factory- or field-test software to run on the SDS-100. The SDS-100 is suitable for performing any drive test that can be performed at the interface. The event-driven logic analyzer can coexist with either product. All three products include IBM PC-compatible add-in cards, and the controlling software executes on the personal computer.

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SCSI-drive makers plan to combine the merits of embedded- and dedicated-servo systems to improve track following and seek times.

their drives that have VCMs. In fact, the newest designs use the straight-arm technology pioneered by Control Data. The straight-arm actuator has lower mass and helps decrease access time. Control Data, Maxtor, and Micropolis have used the technology to reduce the average seek times of their latest product offerings to less than 18 msec.

Priam uses a linear actuator and offset heads. In this technique, the adjacent heads are offset side to side to allow for reduced spacing between platters. The company claims it obtains better reliability from the shorter stack of platters, which allows the manufacturer to use the external spindle motor. Century Data's Cast Div uses similar techniques in its half-height, 5¼-in. 10000 and 14000 Series products, which store 87M to 170M bytes.

You should also consider the servo system used on drives with VCMs. Some drives employ a dedicated servo surface and dedicated servo head. Others embed servo information in each sector on the disk.

The higher-performance drives tend to use a dedicated surface because the servo head continually reads head-location information. In these drives, the controller immediately knows when the head goes off track. With an embedded servo, the controller would not detect an off-track condition until the head crossed the next sector boundary. Such an off-track condition could cause data to be written on the wrong track. A dedicated servo surface also allows you to do a head swap in zero time because the controller constantly monitors location data. The dedicated surface also seems to improve track seek times.

Quantum is the biggest advocate of embedded-servo schemes. The company claims that an embedded servo

SCSI and removable media

System designs that implement SCSI can also take advantage of removable-media peripherals with embedded SCSI controllers. These devices are logically equivalent to Winchester disk drives—operating systems can't tell the difference. You can use these direct-access SCSI devices in your system design either with a Winchester or in place of a Winchester.

For example, consider Ricoh's RH-5261 removable Winchester drive, which stores 22M bytes. The drive conforms to the standard full-height, 5¼-in. size. The drive costs $830 (100), requires 20W of power, and employs a linear actuator. Although it's not a performance match for fixed drives, the Ricoh product specs an 85-msec access time, a 3-msec command-decode time, and 0.625k-byte/sec data transfers. The drive implements the mandatory portions of the CCS and most of the options commonly used by Winchester vendors.

Data Technology Corp also offers a removable-media drive with an embedded SCSI controller. The 10M-byte Taketen product uses floppy media and floppy-disk recording techniques. The disk media, however, are contained in hard-plastic jackets with metal hubs. The drive's 65-msec average seek time rivals that of low-cost Winchesters, but the product transfers data at less than 300k bytes/sec. Data Technology offers the 5¼-in., half-height drive and host adapter to personal-computer users for $1085. OEMs can expect to pay approximately $500 (1000) for the drive.

In the two removable products discussed thus far, the SCSI interface allows the operating system to handle write-protect and cartridge-removal functions. In earlier removable products, the ST-506 interface was unable to handle such functions. In fact, in those early ST-506 drives, unwanted write protection or untimely removal could result in write faults and loss of data.

The removable-media products can serve in applications ranging from archiving to security-sensitive situations that require you to lock up data cartridges. Another class of products serves rugged-environment applications. For example, Magnesys offers a solid-state removable-cartridge system that emulates a Winchester. The Magnesys Electronic Drive includes a SCSI controller and costs $879.

You can choose from 360k- and 720k-byte cartridges for the Magnesys drive. The product complies with the CCS and features a 30-msec average-access time. The error rate for the solid-state drive is virtually zero, and the product transfers data at the standard 1.5M-byte/sec SCSI rate.

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Manufacturers of embedded-SCSI Winchesters

For more information on embedded-SCSI drives such as those discussed in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

Atasi Corp
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Fujitsu America Inc
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provides superior track-following capabilities. In addition, the company points out that in dedicated servo drives, the servo head can be several platters away from the read/write head in use. Dedicated servo drives also use an entire surface just for servo information. The drives therefore require a second read channel for the servo data.

Toshiba's MK-150 family of products uses dedicated servo surfaces, but in these drives, the surface is located near the physical center of the stack of platters. In contrast, most drives use the bottom of the bottom platter as a servo surface, because the read current constantly present in the servo head interferes with the operation of the adjacent head, and when a drive uses the bottom of the bottom platter, the platter isolates the servo head from the other heads.

The full-height 5¼-in. Toshiba drives store 76M to 152M bytes and sacrifice the use of the data surface adjacent to the servo surface. The center-stack servo, however, improves the accuracy of the read/write head location, which is controlled by the dedicated servo surface. The improvement results from the smaller physical distance between the servo surface and the farthest head.

For the next generation of track- and bit-density gains, you can expect manufacturers to implement embedded- and dedicated-servo schemes in the same drive. The dedicated surface will serve in track-seek and head-swap operations, and the embedded-data technique will improve track following. Century Data's Cast Div has already implemented such a design in its 14000 product family. **EDN**

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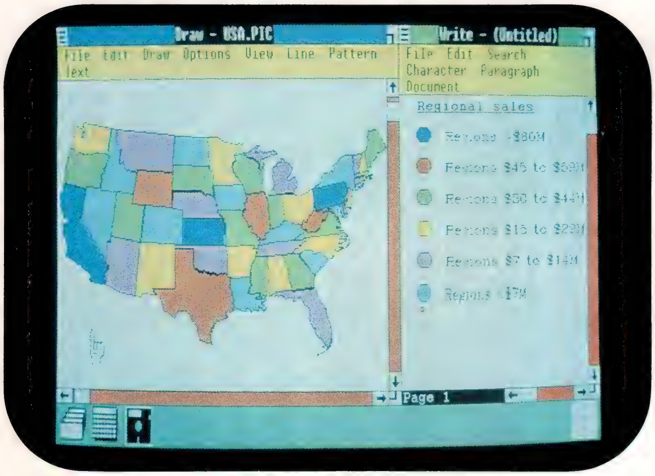
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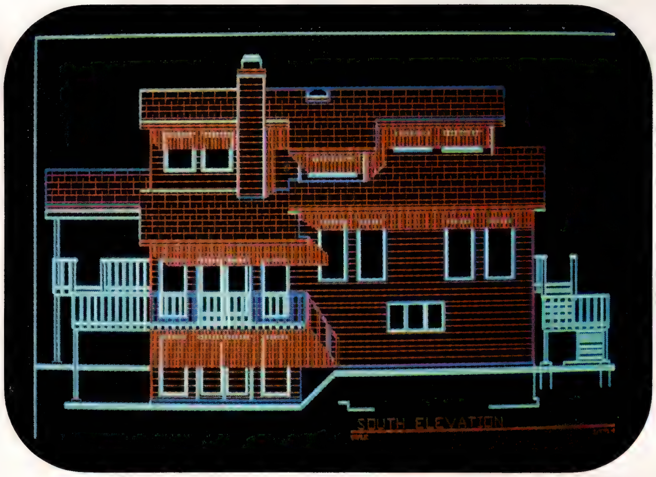

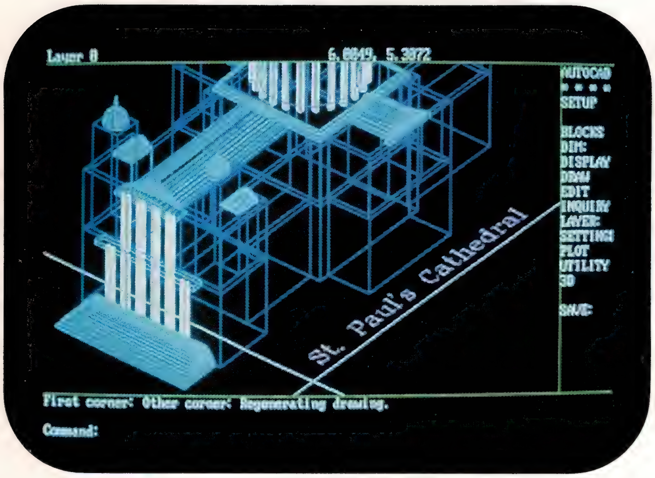

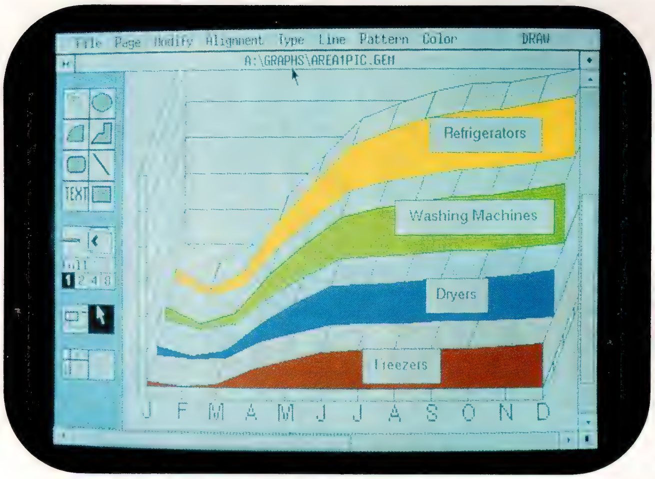

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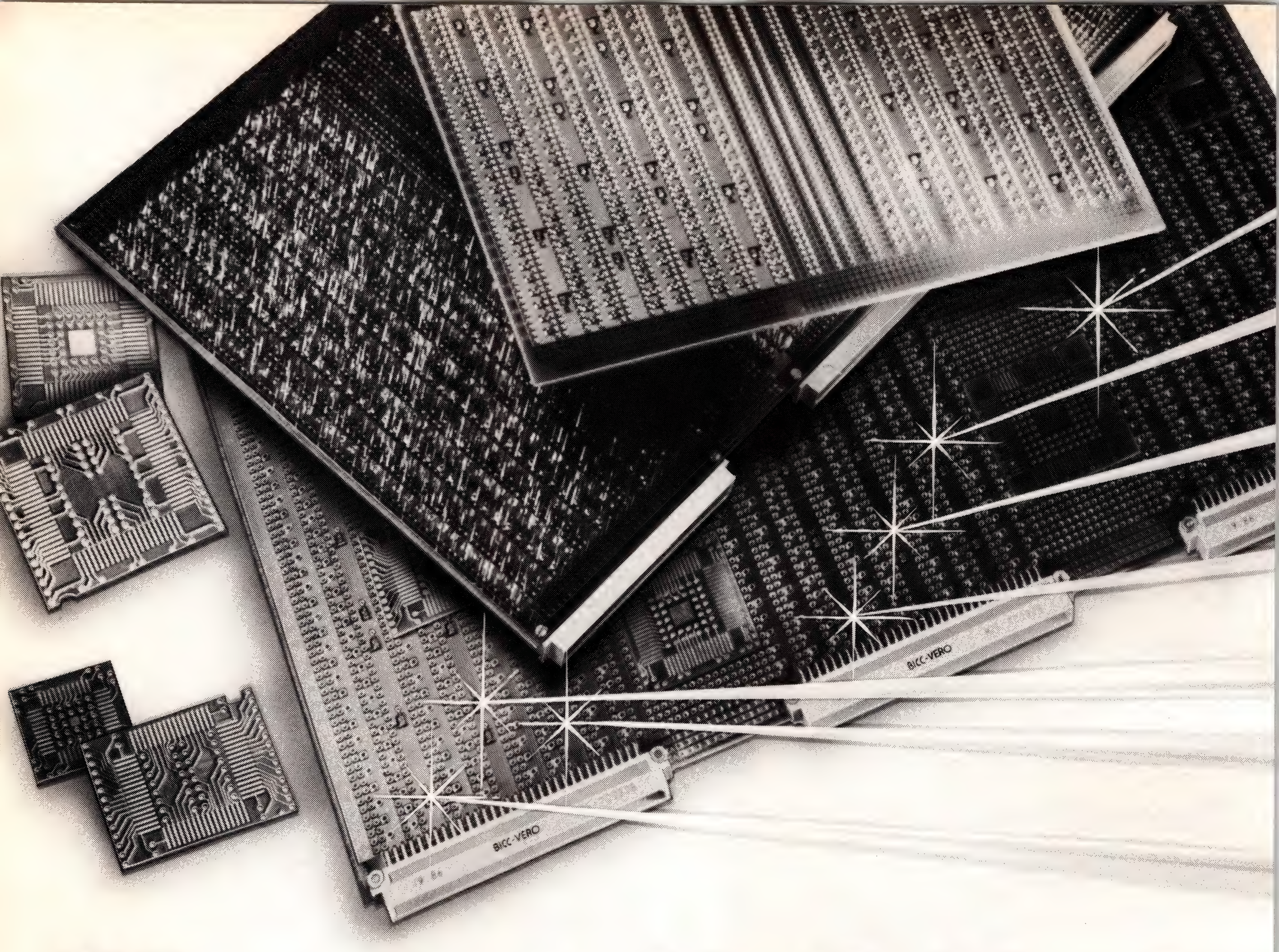

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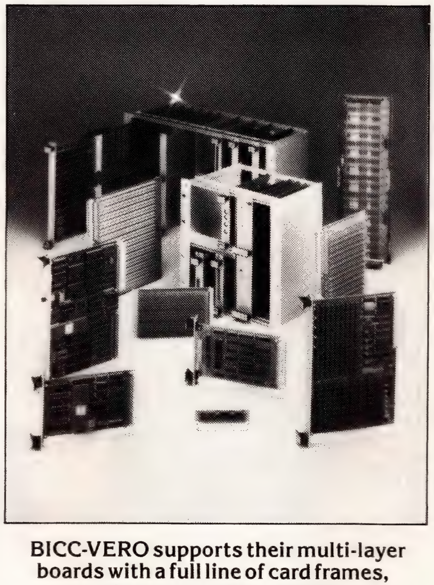

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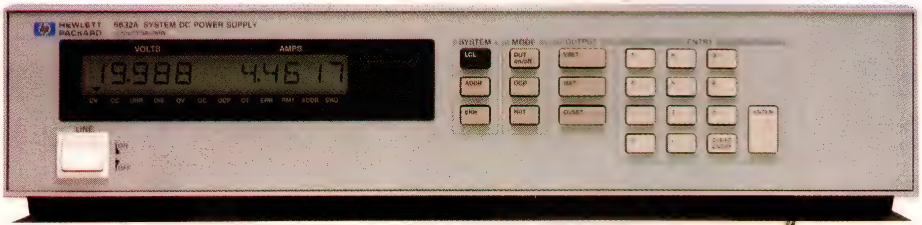

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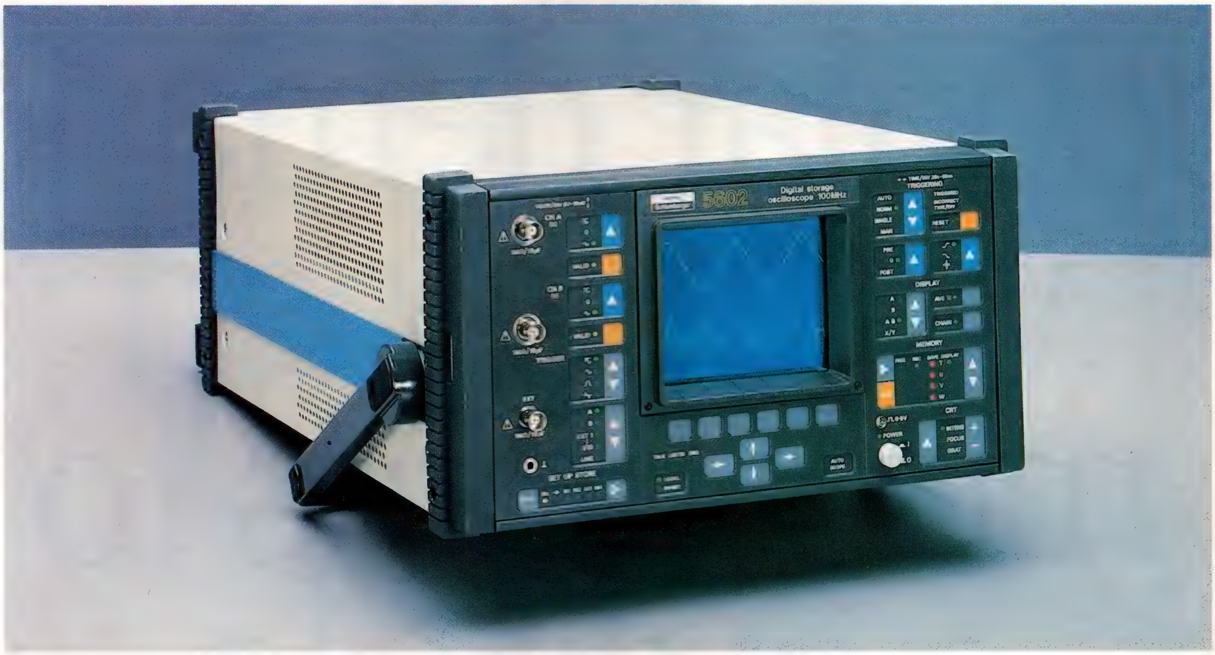

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EDN's Hands-On SMT Project—Part 1

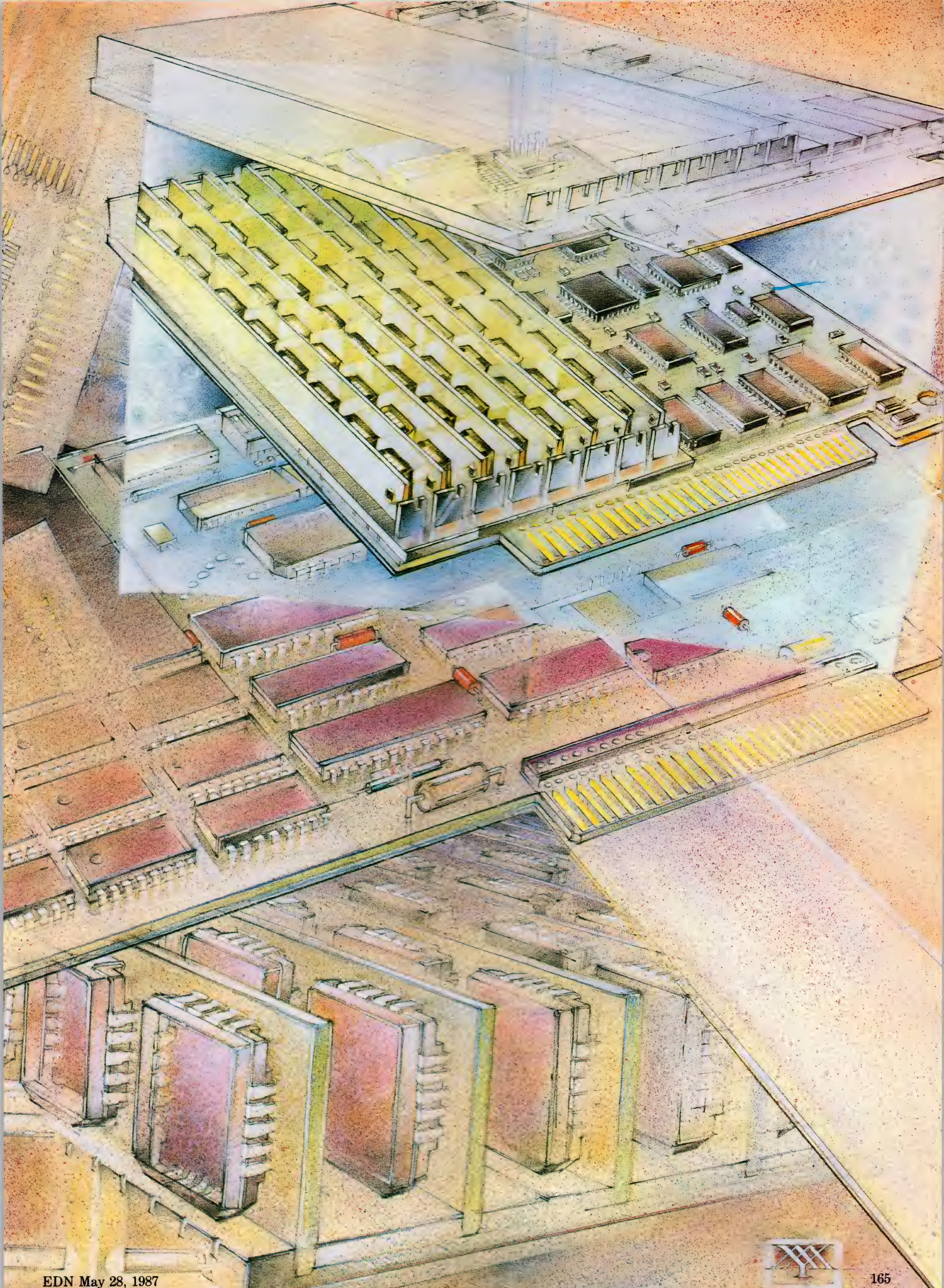
The promise of surface-mount technology

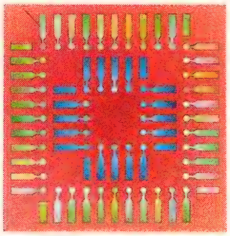
EDN set out to convert an existing through-hole pc board into a version populated by surface-mount devices. The challenges we faced while designing the SMT version and supervising its fabrication and test illustrate the problems you might encounter when pursuing SMT's benefits. This 5-part series, which will run in consecutive issues of EDN, chronicles this 18-month project. We begin at the beginning.

Surface-mount technology purports to compress your through-hole designs by more than half, make them easy to build, increase their reliability, and what's more, perform all of these feats while reducing manufacturing costs. We wondered whether SMT could meet the benefits attributed to it and, if it could, what difficulties might deter designers from enthusiastically embracing it. To investigate the promises of this technology and the difficulties involved in implementing it, we undertook to convert a full-length, through-hole IBM PC memory board into a

Steven H Leibson, *Regional Editor*

Illustration by Michael Young





half-length, surface-mount version.

Our project began with research for a report on information resources available to engineers contemplating SMT designs (**Ref 1**). Our preliminary research took us to Expo SMT (Los Gatos, CA, (408) 354-0700) in October 1985. At that show, we talked with vendors of SMT components and assembly tools and with several consultants. Although enthusiasm at the show ran quite high, experts estimated that only 5 or 10% of new electronic products designed in the US take advantage of SMT. This evidence of SMT's lack of popularity suggested the challenges that we might face in our hands-on project.

Photo by Bill Farrell, the Photo Works

Complex SMT designs demand the use of CAD systems for pc-board layout because of small trace and pad geometries. This CDX-50000 workstation from Cadnetix Corp became an essential tool for EDN's SMT project.

Convert an existing product

Although we could have chosen to create an original SMT design, we decided to convert a product based on through-hole technology to one based on SMT. This conversion approach would allow us to compare product size and manufacturing cost.

The same approach will serve you well in your first SMT endeavor. If you encounter delays, your company can continue to market its existing, through-hole product while you fix the bugs in your SMT design and in your SMT process. The pressure to get the new product to market will be substantially lessened if your company already offers a through-hole version that it can continue to sell.

The reasons for a cautious approach are simple. The newness of SMT creates the potential for several types of design errors that aren't so much of a problem when designing with through-hole components. For instance, you must be careful to specify SMDs that exist (as opposed to the devices that will appear in SMT packages "any day now"), to design to worst-case timing specs, and to pay careful attention to device power dissipation.

Availability problems

SMDs still suffer from spotty availability and long lead times. Moreover, because surface-mount devices are so small, vendors can pack a lot of product in one bulk package: For example, a 7-in. reel of SMD capacitors packaged on 8-mm embossed tape holds 2500 to 4000 parts. This bulk packaging provides a strong incentive for you to minimize the number of different devices your design em-

The SMT Association

Founded in January 1984, the SMT Association (SMTA) provides a forum for companies and individuals to exchange information about surface-mount technology. The national organization publishes a monthly newsletter, conducts technical seminars, and assists in the formation of local chapters. In addition, the SMTA sponsors several technical committees that are developing voluntary standards for components, computer-integrated manufacturing, pc-board design, workmanship, and testability. Dues range from $50 for individual memberships to $350 for international memberships; corporate memberships cost $295. For more information, contact the SMTA, Box 1811, Los Gatos, CA 95031; phone (408) 354-9275.

ploys, and it can create problems for you during the breadboard and prototype stages, when you need only a few parts.

Many designers discover heretofore unrealized timing problems when converting through-hole designs to SMT. The timing problems appear to be caused by two factors. First, ICs encased in SMT packages tend to run faster than the DIP versions, even though identical silicon die reside inside the packages. SMT ICs run faster because the lead frames are smaller and the leads are shorter. The smaller dimensions decrease propagation delays and lower capacitances. Many SMT experts say you can expect to see SMT components exhibit minimum, instead of typical, timing characteristics because of the smaller packaging. Second, an SMT board's traces are also shorter, further reducing signal-propagation delay and trace capacitance.

You can also encounter heat dissipation problems with SMT assemblies because of the incredible packing densities that can be achieved with the technology. If you take an existing design, shrink the assembly to 50% of its original size, and package the new design to reflect the compaction, you might find that your new, compact product is literally too hot to handle.

We wanted a product with a good mix of device types to find out if SMD availability would be a problem. Also, we wanted a product that would benefit from the reduced size of SMT components. AST Research's Rampage! EEMS memory board became our prime candidate. The board incorporates a few passive components, TTL logic, PLDs, PROMs, switches, connectors, and a large block of RAM. Most of these components were displayed at Expo SMT by several vendors. In addition, the board was receiving quite a bit of trade-press attention because AST's EEMS specification competes with the Lotus-Intel-Microsoft (LIM) spec (see **box,** "AST, Rampage!, and the EEMS").

An additional reason for choosing a product from AST Research related to our plans for CAD development of the SMT project board. We planned on using a Cadnetix pc-board design workstation, and AST uses them for its designs. We hoped to obtain the design data for the Rampage! on tape, eliminating the possibility of error from manual transcription of the product schematic. We chose Cadnetix because that company is located in the same city as the author, providing ready access to workstations and to technical assistance, and because the author, a former design engineer at Cadnetix, has more than a passing familiarity with Cadnetix systems.

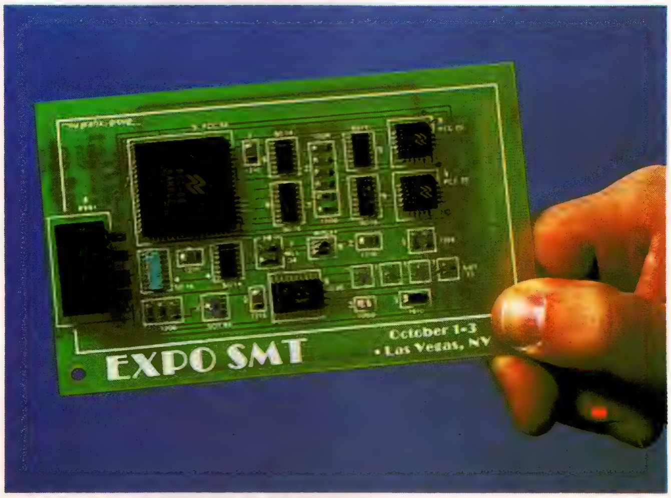


Photo by Bill Farrell, the Photo Works

This SMT demonstration board came off the surface-mount assembly line at the Expo SMT '85 show. Although the board showcases the use of SMDs like PLCCs, SOICs, connectors, and passive devices, it doesn't illustrate many of the problems you might encounter with a real design because it's too simple.

Initially, we planned to build a version of the Rampage! using SMT to achieve 8M bytes of storage on the same pc-board size as the original product. Although one through-hole Rampage! board can accommodate 2M bytes of memory, the EEMS allows you to put four Rampage! cards in a computer system to achieve 8M bytes of memory. We estimated that if all we needed to do was quadruple the size of the Rampage! memory array, an 8M-byte version could be achieved in the same form factor.

Before we could accomplish that conversion, however, we needed to meet with AST, con-

Breaking the IBM PC's 640k-byte memory barrier

The IBM PC's original design allocated only the lower 640k bytes of the 8088 μP's 1M-byte address space to applications programs (**Fig 1a**). Within two years of the PC's introduction, however, software vendors started to bump into the computer's 640k-byte memory limit. For example, many PC users found that their computers lacked sufficient memory to hold the enormous Lotus 1-2-3 spreadsheets that they needed to manipulate. Several vendors of IBM PC expansion products set out to remove this limitation.

Lotus Development teamed up with Intel and Microsoft to produce the LIM EMS (Lotus/Intel/Microsoft Expanded Memory Specification). The EMS specifies a block-switching scheme in which four contiguous, 16k-byte page frames are located somewhere in the memory space from address $C0000 to $EFFFF (**Fig 1b**). The 8088 accesses independent 16k-byte blocks of the expanded memory through this 64k-byte window by employing four address-translating page registers on the EMS board. Using this scheme, an application program can address 2M bytes of EMS RAM, but it can address only 64k bytes at a time. The LIM EMS specifies a software interface to an expanded-memory-management software routine that manages the EMS RAM and isolates the application program from the EMS hardware.

Because the EMS limits memory-block switching to segments C through E, above the operating system's program space, applications programs can only use EMS memory for data storage or for storing program overlays. MS-DOS can't accommodate noncontiguous program space above the 640k-byte threshold. Also, because only 64k bytes of the EMS memory are accessible at any time, the applications program must explicitly manage the memory-block switching for data-storage requirements exceeding 64k bytes.

AST Research's EEMS (Enhanced EMS), a superset of the LIM spec, offers two improvements to the LIM concept. The EEMS increases the number of page registers from four to 64, thus mapping EEMS RAM into any unused memory locations in the PC's 1M-byte address space (**Fig 1c**). Because its page registers can map EEMS memory below

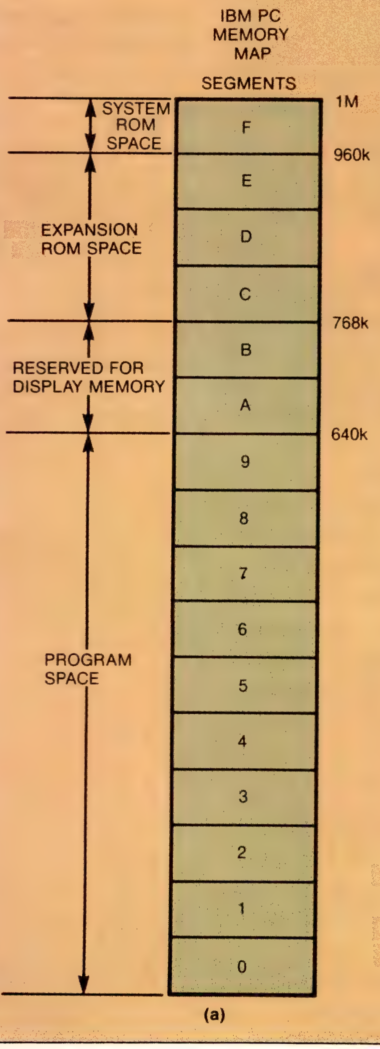
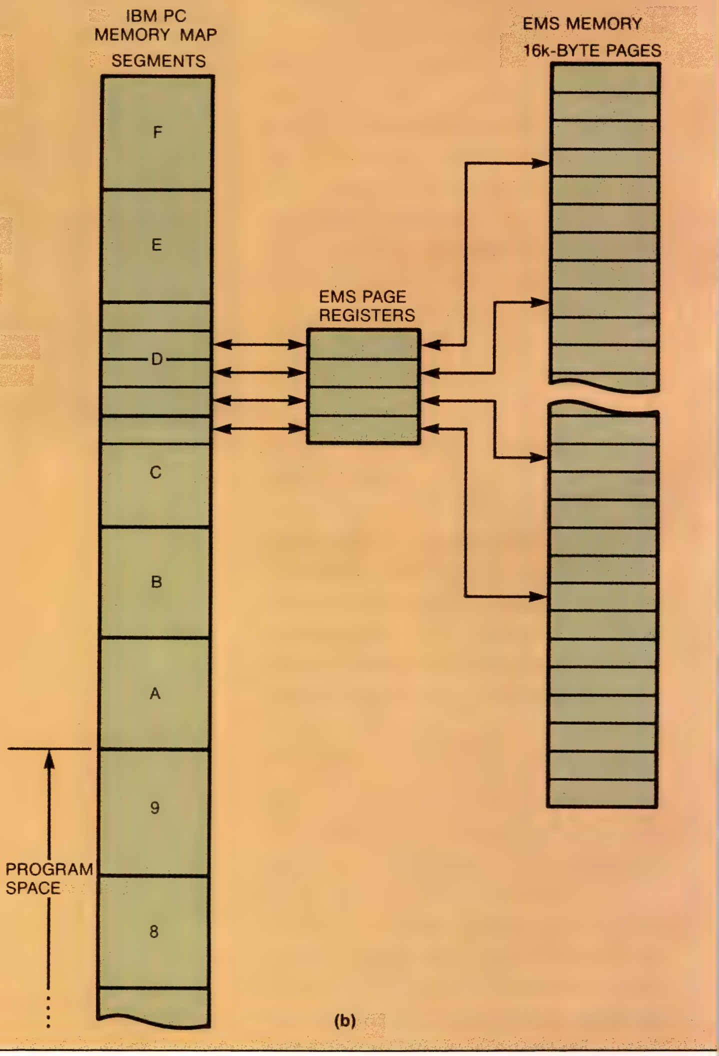
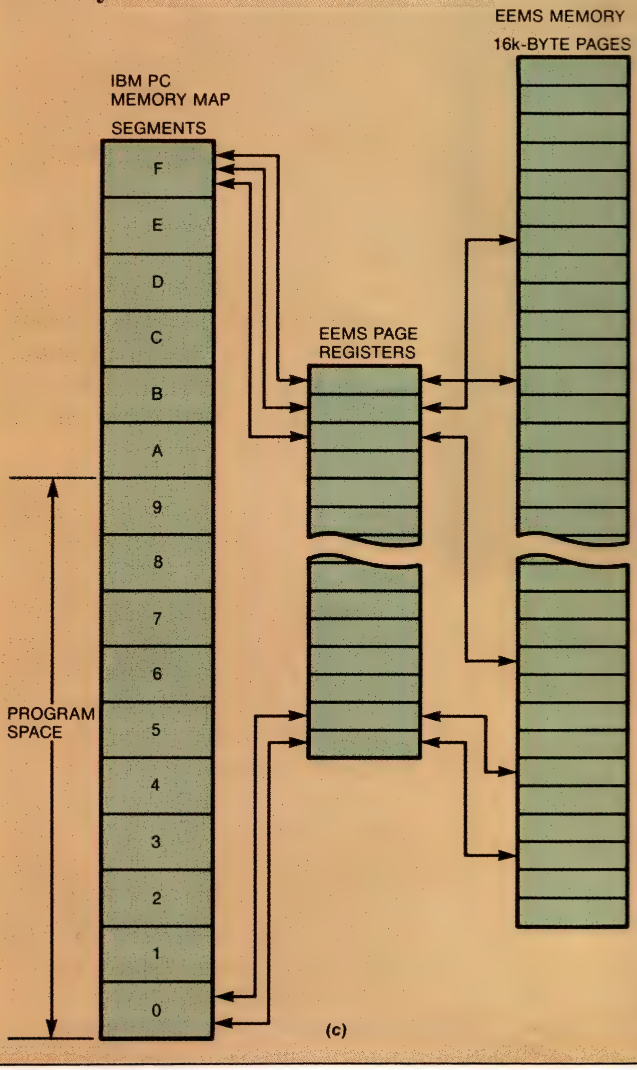


Fig 1—The memory map of the 8088-based IBM PC **(a)** limits you to 640k bytes of memory for applications software. A block switching scheme called EMS **(b)** uses a 64k-byte window in the PC's upper-memory space to access as many as 2M bytes of EMS RAM, but because this memory is not contiguous with the lower 640k-byte block, applications programs can only use this additional memory for data storage. The enhanced EMS (EEMS) scheme implemented by the Rampage! **(c)** can switch additional memory into any 16k-byte frame within the 8088's 1M-byte address range, thus supporting multiple resident programs and multitasking operations.

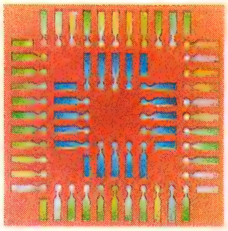


the 640k-address level, into the PC's program space, an EEMS board allows multitasking software to swap entire applications programs in and out of the memory space. AST maintained compatibility with the EMS through its memory-manager software interface so that applications programs written to use EMS memory managers also work with EEMS boards.

The first product from AST to implement the EEMS was the Rampage! memory card, which accepts 2M bytes of RAM. AST's memory-management software and utility programs allow the PC to use Rampage! memory as a RAM disk and as a print buffer. Desqview, an operating-system software shell for MS-DOS by Quarterdeck Office Systems (Santa Monica, CA, (213) 392-9701) and supplied by AST with the Rampage! hardware, provides a multitasking environment that can use all 2M bytes of memory on the Rampage! for applications-program storage. Desqview supports as many as four Rampage! cards, allowing you to assemble 8088-based PCs with 8M-bytes of memory.



vince the company that the Rampage! was a fine candidate for SMT conversion, and convince AST's management that it should hand over sufficient engineering documentation to allow us to reproduce the Rampage! using SMDs. That meeting occurred on December 18, 1985.

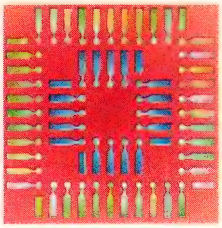


Adjusting our assumptions

At first, the representatives from AST wanted to understand why a technical publication like EDN wanted the complete plans for one of their latest and hottest products. They wanted to know if Cahners Publishing planned to enter the pc-board business. We assured them that was not the case and proceeded to explain the project and discuss the technical merits of our plans. We soon discovered that one of our fundamental assumptions was wrong. The Rampage! control circuits could drive only a 2M-byte RAM array. An 8M-byte memory requires almost four times the control circuitry used on the 2M-byte product.

We journeyed to Irvine-based AST Research to obtain the engineering documentation necessary for re-creating the Rampage! EEMS memory board using SMT.

Thus, an 8M-byte Rampage! on one card would not fly. Even using SMDs, 8M bytes of memory plus the enlarged control section simply would not fit within the existing board's form factor. The IBM PC constrains expansion-



board size, which prevented us from enlarging the pc board to accommodate the extra circuitry.

After a little more discussion, we settled on building a 2M-byte Rampage! using a "short-slot" form factor. From a technical viewpoint, this approach has much stronger appeal. The conversion would not change the board's fundamental design, so we could focus on the SMT aspects of the project.

From a marketing perspective, a short-card Rampage! would open new avenues of opportunity for the product. IBM PC/XTs and many similar computers incorporate one or more expansion slots that do not accommodate full-length boards like the Rampage!

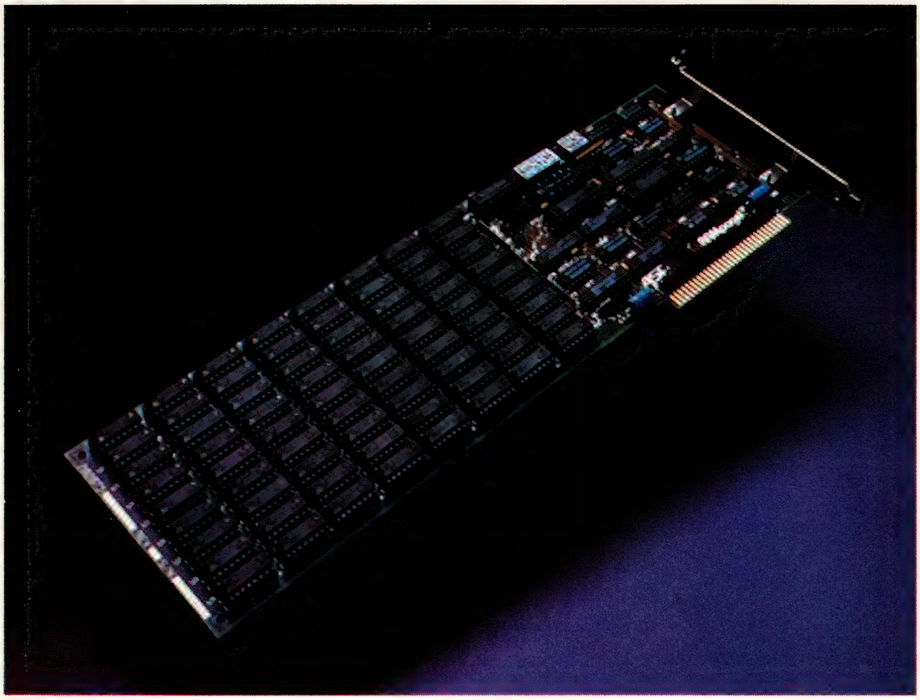


Photo by Bill Farrell, the Photo Works

Accommodating 2M bytes of RAM on one card, the AST Rampage! and its associated software greatly enhance the capabilities of 8088-based IBM PCs and compatible computers.

In addition, several hard-disk-on-a-card expansion boards occupy 1.5 expansion slots, transforming a full-length slot into a short berth. A short-card easily snuggles into these smaller slots. Thus, a short-card, SMT Rampage! would fit in many more available slots than the original product.

This example illustrates SMT's ability to let you choose between building more capability into an existing form factor or reducing the size of an existing product. Our original concept was to attempt the former approach, but we, along with AST, concluded that the latter solution stood a better chance of success.

Keeping people in the loop

AST provided us with the necessary documents and a sample Rampage! for comparison purposes. Unfortunately, the schematics had not been entered into a Cadnetix system at AST so we would have to make that conversion as part of the project. This was the first of many instances in this project where a human was responsible for transferring information to a computer-based tool. Although many vendors bill SMT as a highly automated technology, people aren't out of the loop yet by any stretch of the imagination.

As a next step, we needed to acquire some SMT design expertise. SMT-based board design differs radically from through-hole board design. The SMT pc-board designer has the primary responsibility for making sure the board is manufacturable, once the electrical design is proven. Component layout, part orientation, and pad design all determine the quantity of defects a manufacturing department will encounter. No amount of tuning will allow an SMT manufacturing process to compensate for bad design.

Because we did not have the time or money to make several attempts at designing an SMT pc board, we selected the more economical approach of obtaining expert training in surface-mount pc-board design so we could design our board right the first time. For companies contemplating an initial SMT design, the cost of training may look like an extravagance. However, one failure that results in an unbuildable board will cost you far more than a design class. Alternatively, you could employ a design service, either to design your SMT board or to make sure your design is manufacturable.

In training for SMT

SMT Plus offers a smorgasbord of services, including training, design, and consulting. The company still teaches the class we attended, "Designing for Manufacturability," but under a new new name: "SMT Fundamentals of Product Design." The 2-day, $950 class covers SMT packaging, component selection, substrates for SMT assembly, land-pattern design rules, design for testability, and considerations for using CAD systems to do SMT design. The company targets the class at pc-board designers with little or no SMT background.

Designers that have attended the fundamentals course or have designed at least one SMT board may be interested in a new class taught by the company called "Advanced Design Techniques." This class, which also costs $950 and lasts for two days, covers techniques for generating your own design rules and pad patterns, for managing thermal problems with SMT assemblies, and for selecting CAD systems with an eye toward features that aid SMT design.

Photo by Liane Enkelis

You can minimize false starts and costly errors when you begin to use SMT by attending a class in SMT-based design like "Designing for Manufacturability," taught by Jim Blankenhorn, president of SMT Plus.

Backing up these classes are the company's CAD-based design and prototyping services. SMT Plus designed 70 SMT boards on a contract basis for various customers in 1986, so its land patterns and design rules have been thoroughly tested. The company guarantees its designs to be manufacturable through the client's manufacturing process. If you prefer to do your own pc-board design, you can also arrange for SMT Plus to review your layout. In addition, the company can build SMT prototype assemblies in a shop maintained on the premises. Classes taught at the company's San Jose facility include a visit to the prototype shop.

Surface Mount Technology Plus supplied our SMT board-design education through a seminar called "Designing for Manufacturability" (see **box,** "In training for SMT"). We met Jim Blankenhorn, the company's president, at Expo SMT and arranged to attend the 2-day class on March 10 and 11, 1986. The class, attended by representatives of eight other companies, focused on surface-mount devices and on making the design manufacturable.

The importance of pad design

The course taught us that pad design is one area in which through-hole design experience won't benefit the conversion to SMT designs. For through-hole boards, a 35-mil hole in a 50-mil pad is about as good as a 40-mil hole in a 60-mil pad for manufacturing purposes. However, every mil counts in SMT designs. A 5-mil variation in one pad dimension can make the difference between a consistent, reliable solder joint and a persistent manufacturing problem.

The reason small changes in pad design have large effects on making a board manufacturable is rooted in the fundamentals of the SMT manufacturing process. For reflow-soldered boards, the volume of solder available to each joint during soldering is directly determined by the pad area multiplied by the thickness of the solder paste laid down during the solder-screen operation: Too little solder creates open joints; too much solder creates short circuits. You also need a reasonable

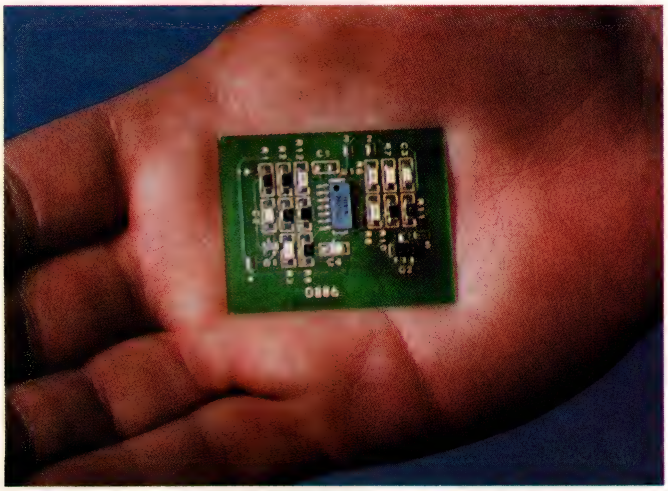
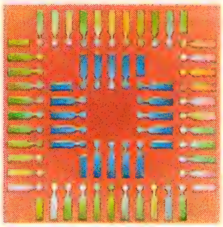


Photo by Bill Farrell, the Photo Works

As a final assignment in the "Designing for Manufacturability" class taught by SMT Plus, we designed a do-nothing pc-board. This board displays the instructor's solution to the problem. Although we gained experience with SMD layout through the assignment, the board's simplicity did not fully prepare us for the many problems we encountered when dealing with more complex circuits.



target zone for the SMD leads (realized by a pad of sufficient size) so that the "onsertion" equipment (the counterpart of through-hole technology's *insertion* equipment) is allowed a little placement tolerance.

Your boards can also exhibit short circuits if pads are too close to each other. Short circuits are especially likely for a board that has passive SMDs wave-soldered to its bottom. Components placed near or next to each other also complicate onsertion because of reduced clearances, increasing the probability of short circuits and device misalignment.

SMT assembly facilities require surprisingly little floor space, as illustrated by this assembly area at SMT Dynamics. One operator in the background tends three onserters. The other three people inspect and test the finished boards.

To design a manufacturable board, you need a set of pad designs that work well. The best way to obtain these pad designs is to acquire them from someone who has used the designs and found them to be effective. Not all pad designs work in all SMT manufacturing processes. Pads that work well for vapor-phase reflow processes may be unreliable when boards are soldered using IR-reflow systems.

SMT Plus claims its pad designs are a good compromise and work in all manufacturing processes. The company supplies pad-design guidelines as part of its design manual, included with the course. SMT Plus designed 70 SMT boards in 1986 and provides a guarantee on its designs: If the board proves not to be manufacturable, the company will redesign it for free. So far, a very few designs have required some minor fixes under this guarantee. These are strong arguments in favor of using the company's pad designs. They've been field proven.

Choosing IC packages

Component selection also influences how manufacturable a board will be. You will have to make many more component decisions for an SMT board design than for a conventional through-hole board. For example, some ICs might come in SOIC (small-outline IC) packages but not in PLCCs (plastic, leaded chip carriers), others might only come in PLCCs, and still others might come in both package styles.

Many semiconductor components, notably power devices and high-pin-count ICs, come only in through-hole versions. If you must use these ICs in your design, you will be forced to use a hybrid, through-hole/SMT manufacturing process.

As a finale to the SMT design course, we piled into cars for a field trip to SMT Dynamics Corp, a contract-assembly shop specializing in SMT manufacturing. There we saw a complete SMT manufacturing floor. The small size of the SMT assembly machinery and the trifling inventory space required to store SMT components make for a very compact

For more information . . .

For more information on the products discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

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SMT Dynamics
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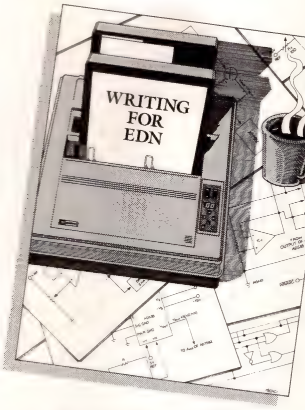

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facility. Gone are the long rows of board-stuffing push lines staffed by one or two dozen people. Instead, one or two operators can supervise a line of assembly machines and turn out large volumes of a high-quality product.

Breaking the bank

Companies like SMT Dynamics fill a need for other firms just starting out with SMT. Costs for SMT equipment are significant: A small prototype facility can cost you $100,000, and large production facilities can cost several millions of dollars. In fact, capital-equipment costs are one of the last major barriers to rapid acceptance of SMT. Many contract-assembly shops now offer you SMT-assembly facilities so you do not need to make that large capital investment. In the next few years, you can expect to see many more firms specializing in SMT assembly. Because these companies build products for many different clients, they can keep the SMT manufacturing machines busy and amortize capital equipment costs over many more boards than can small companies just starting with the technology.

At this point in the project, we had a product design ready for SMT conversion and the training necessary to perform that conversion. Now all we needed to do was select and obtain the components, design and fabricate the pc board, and build and test the assemblies. Piece of cake! **EDN**

Reference

1. Leibson, Steven, "Special Report: Surface-Mount Technology," *EDN*, October 2, 1986, pg 135.

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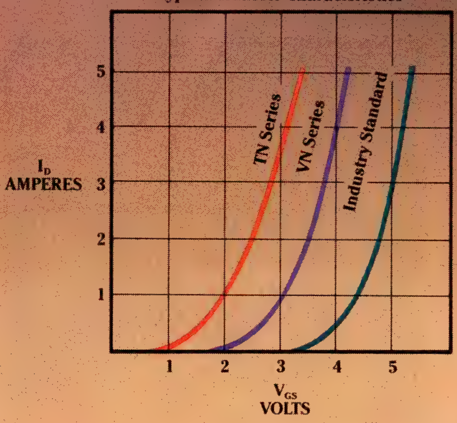

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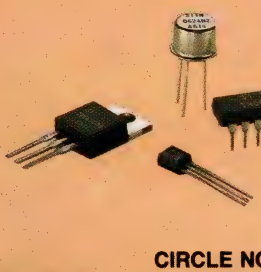

DEVICE TYPE	BV_{DSS} MIN (V)	R_{DS}(ON) MAX (Ω)	V_{GS}(th) MAX(V)
TNO1L	20, 40	1.5	1.5
TNO1A	60, 100	3.0	1.5
TNO5C	200, 240	10.0	1.5
TNO6L	20, 40	0.75	1.5
TNO6A	60, 100	1.5	1.5
TNO6C	200, 240	6.0	1.5
TPO1L	20, 40	4.0	2.4
TP06L	20, 40	1.5	2.4
TPO6A	60, 100	3.5	2.4
TPO6C	160, 200	12.0	2.4

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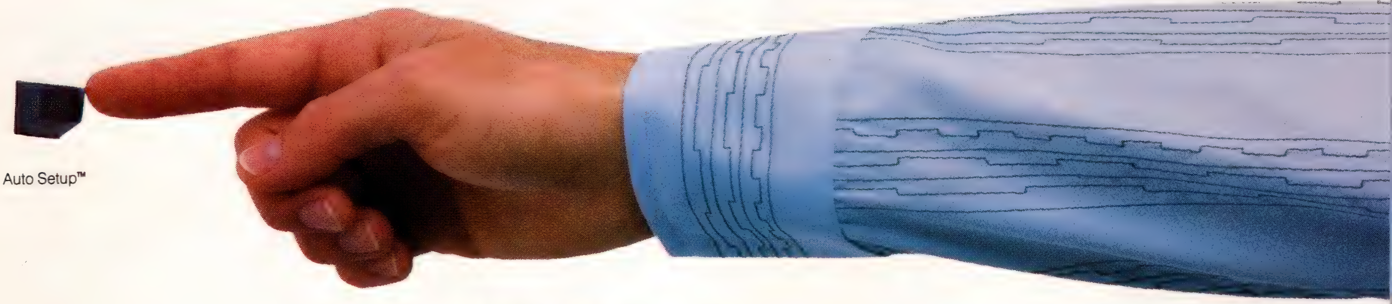

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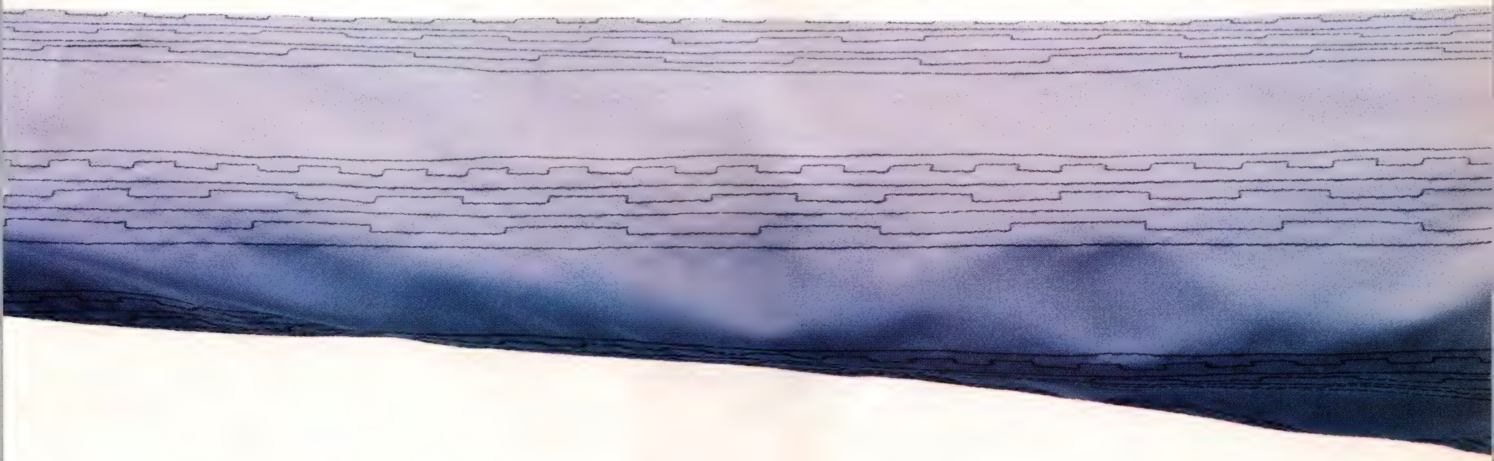

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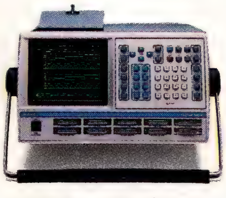

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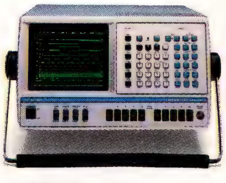

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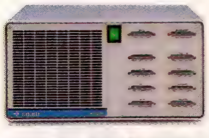

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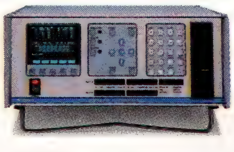

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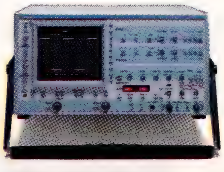

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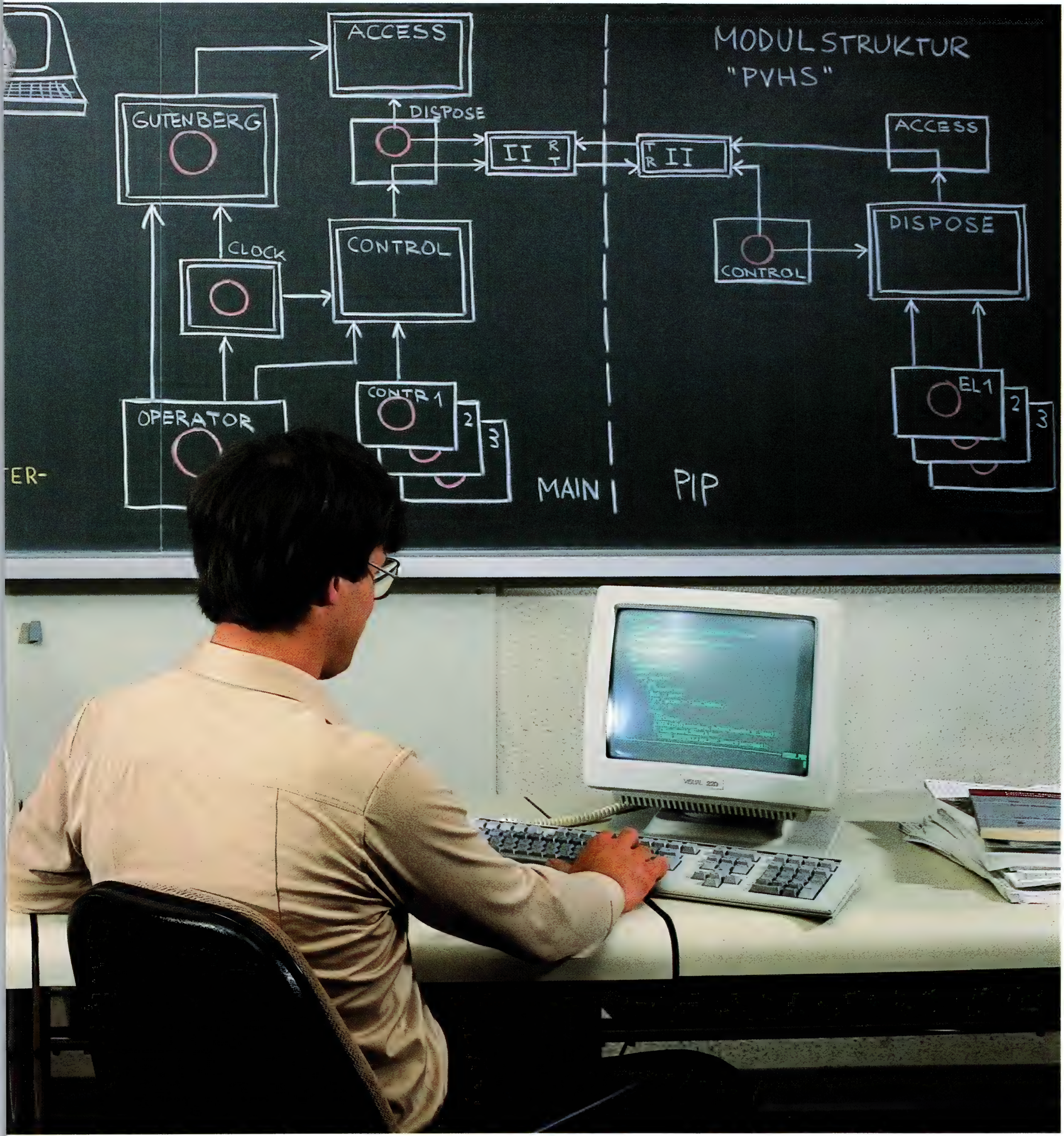

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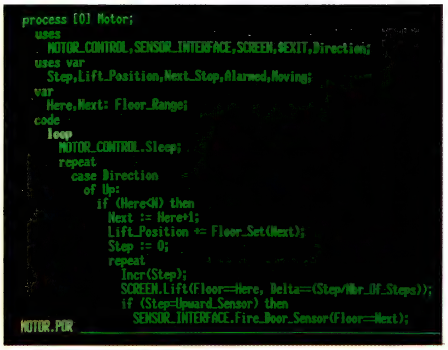
To fulfil this need Landis & Gyr has developed the real-time programming language PORTAL. It has already been in use for a number of years, with considerable success, and is now being made available to a wider public.



```
process [0] Motor;
  uses
    MOTOR_CONTROL,SENSOR_INTERFACE,SCREEN,$EXIT,Direction;
  uses var
    Step,Lift_Position,Next_Stop,Alarmed,Moving;
  var
    Here,Next: Floor_Range;
  code
    loop
      MOTOR_CONTROL.Sleep;
      repeat
        case Direction
          of Up:
            if (Here<N) then
              Next := Here+1;
              Lift_Position += Floor_Set(Next);
              Step := 0;
              repeat
                Incr(Step);
                SCREEN.Lift(Floor==Here, Delta==(Step/Nbr_Of_Steps));
                if (Step=Upward_Sensor) then
                  SENSOR_INTERFACE.Fire_Door_Sensor(Floor==Next);
MOTOR.POR
```

How can PORTAL help efficiently solve your real-time programming problems?

The real-time programming language PORTAL offers many advantages:

A modular approach

allows a problem to be split up into manageable parts with well-defined interfaces. Several programmers may work simultaneously on different parts of the same project.

Parallel processes

with a clear and simple concept of monitors and signals for process synchronisation.

Direct hardware control

at source level, using variables bound to peripheral addresses, and signals bound to interrupts.

A syntax-directed editor

allows convenient, error-free entry and modification of PORTAL programs.

High reliability

most programming errors are detected at compile-time. Run-time tests are automatically included in the code. The maximum stack space required by each process is computed at compile-time, so that stack overflow cannot occur during execution.

An easy-to-use debugger

allows inspection at source level, of a stopped program.

Industrial robustness

PORTAL was developed by industry for industry
and has proved itself in actual customer projects. PORTAL has been successfully in use for several years, both at Landis & G as well as in other firms.

Support of powerful micro-processors

at present, PORTAL is available for the Motorola micro-processo 68000, 68010, and 68020. Code may reside either in RAM or RO

Compilation on high performance computers

PORTAL programs can be developed and compiled on Digital Equipment Corp's VAX/VMS systems (or on a Landis & Gyr PORTALINO workstation).

A complete description of the real-time programming language PORTAL is contained in the follo
ing publication:
PORTAL Language Description,
by Arnold Businger.
Lecture Notes in Computer
Science, No. 198.
Springer-Verlag Heidelberg 1985

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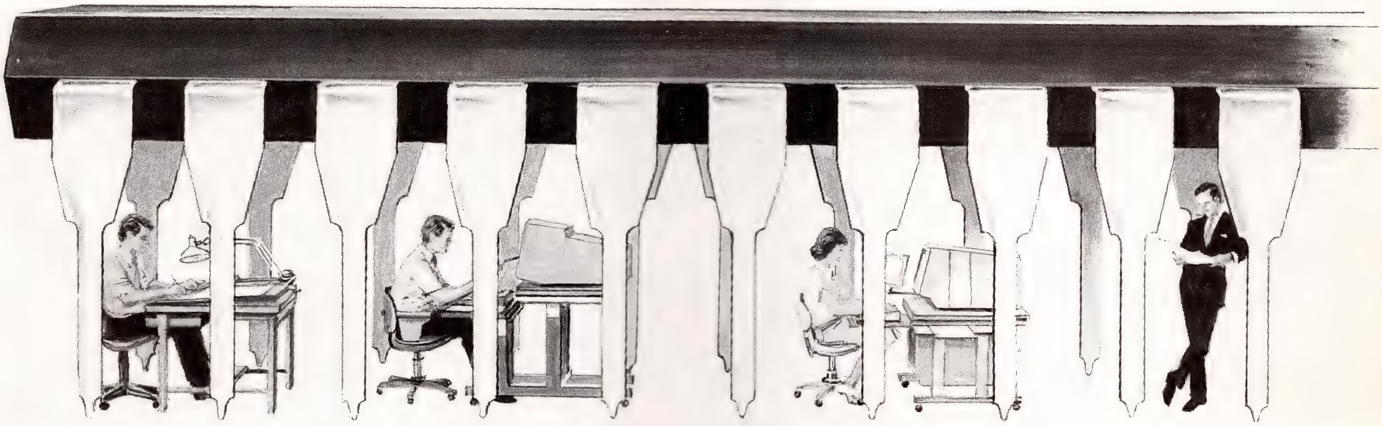

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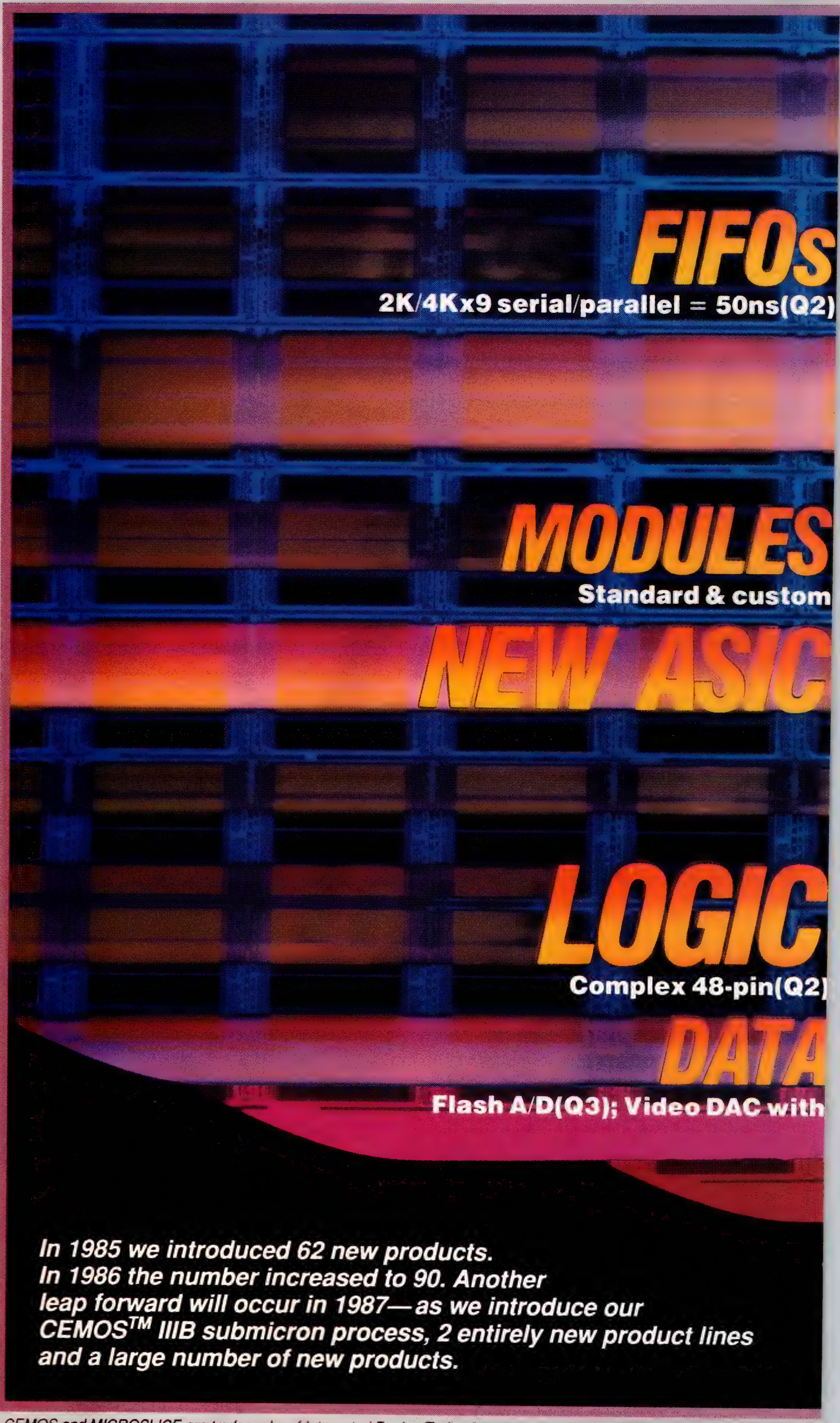

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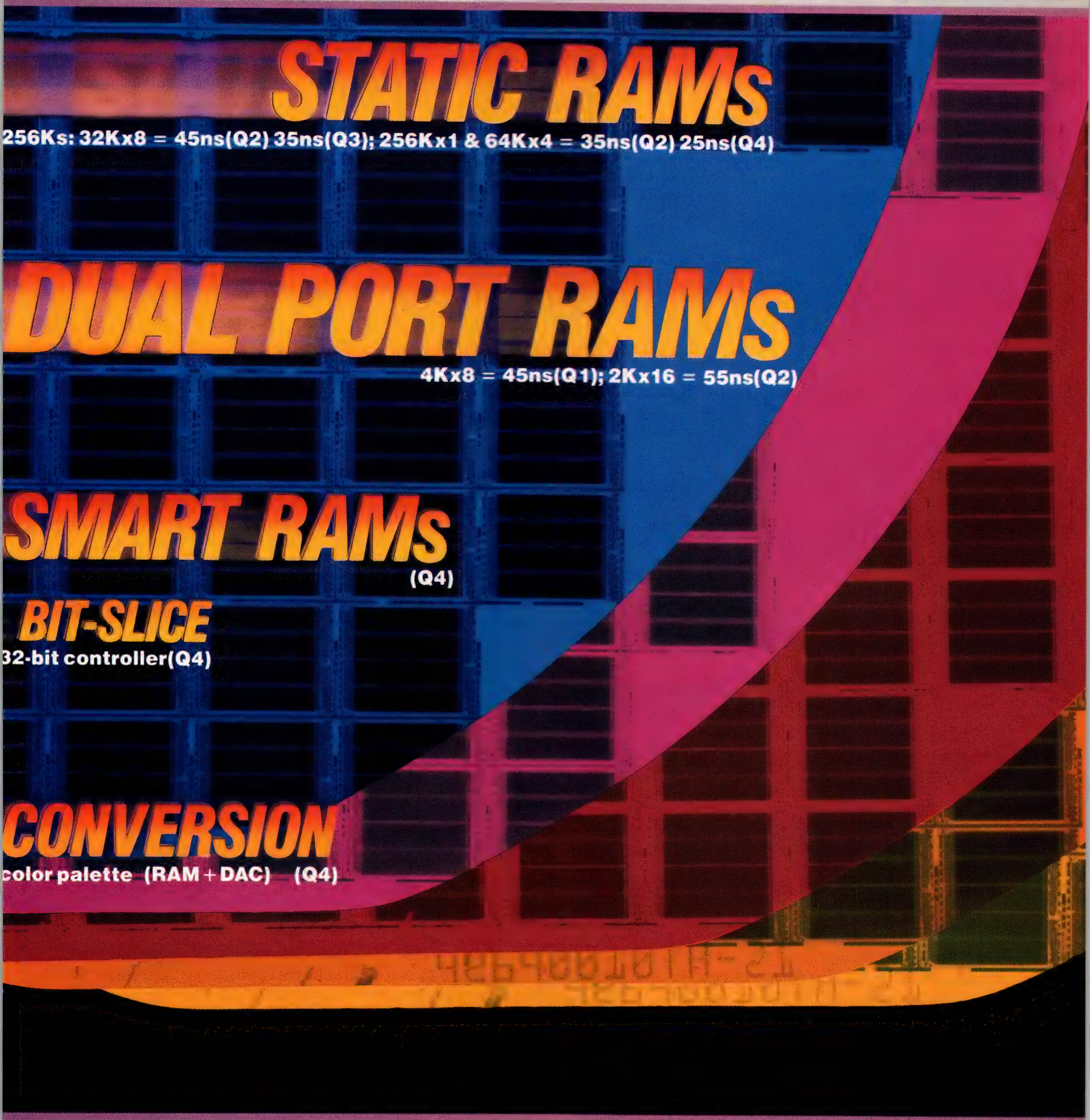

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Cache accelerates operation of 32-bit µP systems

As you move up from 16-bit µP-based designs to 32-bit systems, you'll find it especially critical for your microprocessor to have access to high-speed memory.

Robert Nalesnik, *Fairchild Europe Semiconductor*

A cache, a relatively small portion of high-speed memory that resides between the CPU and main memory, is an essential part of any 32-bit computer design. No other technique in computer design provides more power and capability for a given amount of money. Nonetheless, a cache is more than just a chunk of high-speed memory for a µP to nibble on. A cache may be real or virtual, direct-mapped or associative, unified or split. If you make the proper design choices, your cache will deliver more than 80% of the throughput that a high-speed main memory could provide—at a fraction of the cost.

Regardless of architecture, today's 32-bit VLSI µPs consume instructions and data faster than any dense, inexpensive, dynamic RAMs can supply them. An obvious solution to this memory bottleneck is a main memory consisting entirely of high-speed static RAMs, but

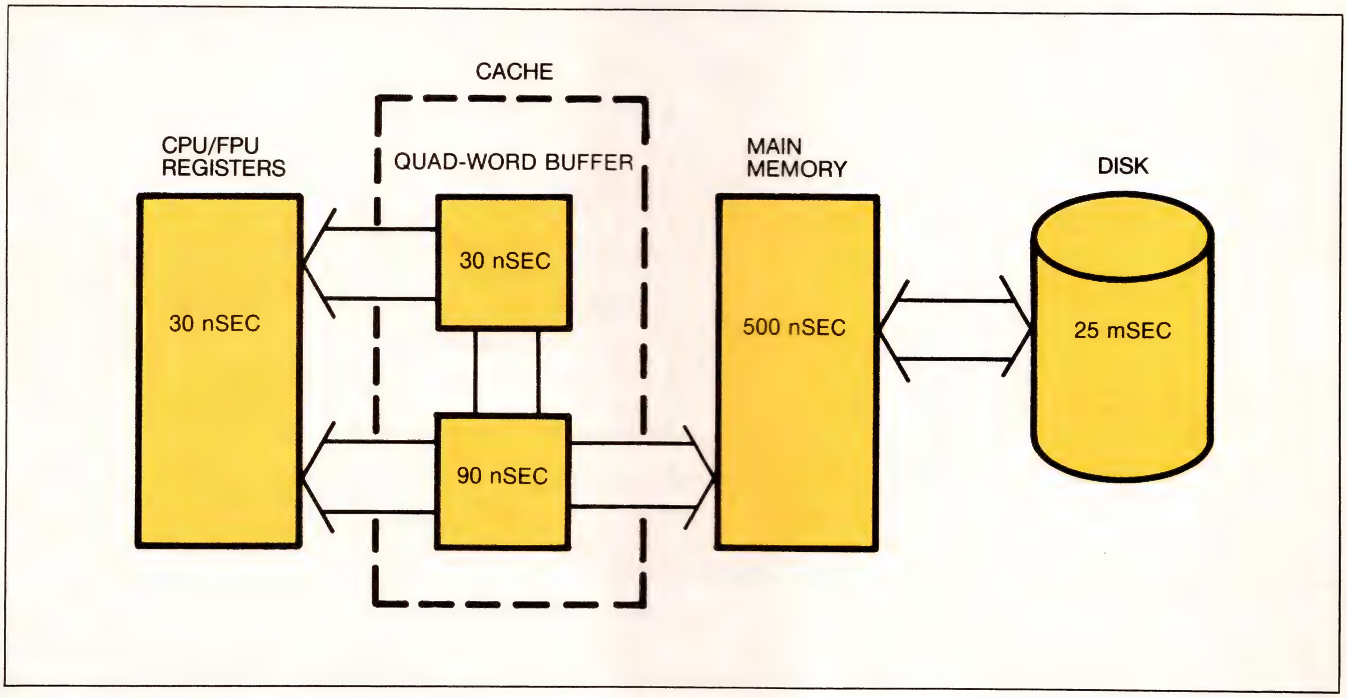


Fig 1—The overall access time of a system *that includes a cache is a weighted average of all the access times associated with each system component.*

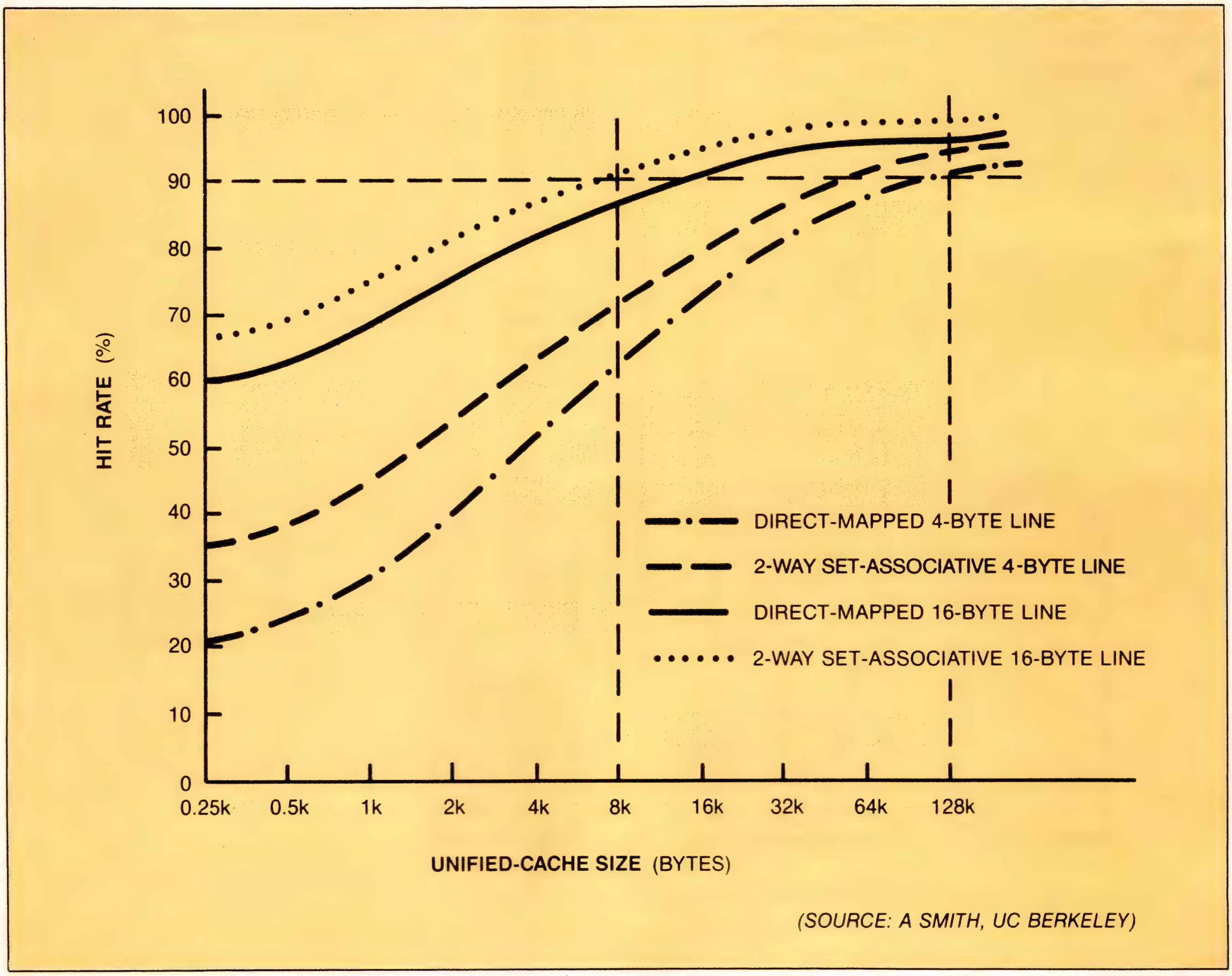
Regardless of architecture, today's 32-bit VLSI µPs consume instructions faster than any dense, inexpensive, dynamic RAMs can supply them.

static RAMs are far more costly, bulky, and power hungry than their dynamic counterparts. Only the highest performance applications can justify using static RAMs for main memory. A cache is the bridge between a slow main memory and a high-speed µP, providing fast access to the block of data and instructions most likely to be required by the µP.

For a cache to be effective, a program must possess a high degree of both temporal and spatial locality of reference. (For a better understanding of the terms you'll find in this article, see the **box,** "Glossary of cache terminology.") In the case of a program that assumes an instruction once fetched will be fetched again in a short period of time, you'll have good temporal locality of reference. Programs that use many loops and frequently used variables and subroutines have a high degree of temporal locality of reference.

If a program relies on the likelihood that after one instruction is fetched, an instruction in a nearby memory location will be fetched soon thereafter, you'll have a high degree of spatial locality of reference. Programs that use sequential instructions and that have commonly used variables in adjacent memory locations have a good degree of spatial locality of reference.

An example of a cache implementation **(Fig 1)** illustrates the effectiveness of a cache in a large-scale computer system. Registers in the CPU have access times of 30 nsec. Each cache contains a quad-word



(SOURCE: A SMITH, UC BERKELEY)

Fig 2—The organization of a cache *determines its hit rate. The simplest approach is also the least effective, as illustrated here. An 8k-byte, direct-mapped, 4-byte-line cache attains only a 60% hit rate.*

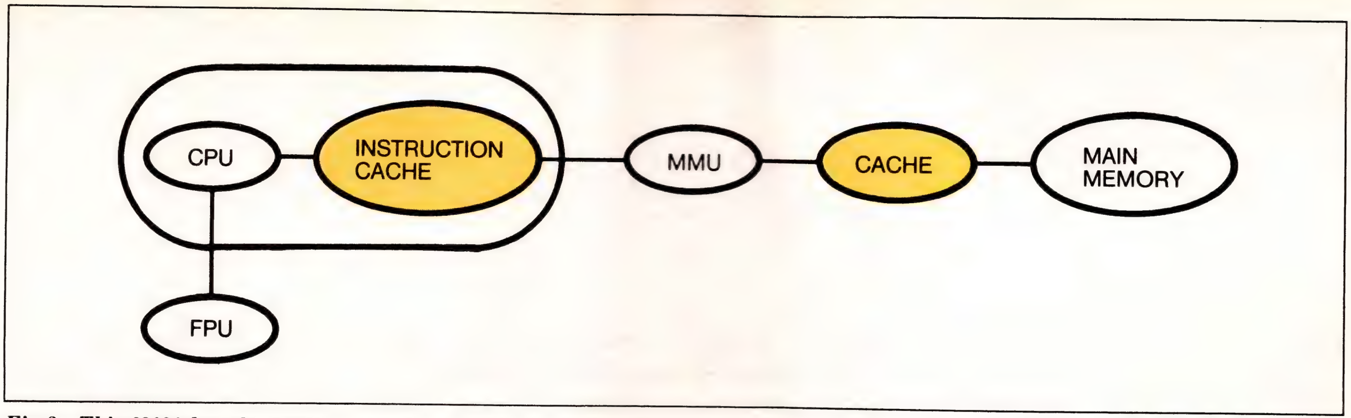


Fig 3—This 68020-based system *includes both an on-chip virtual cache and a larger off-chip real cache.*

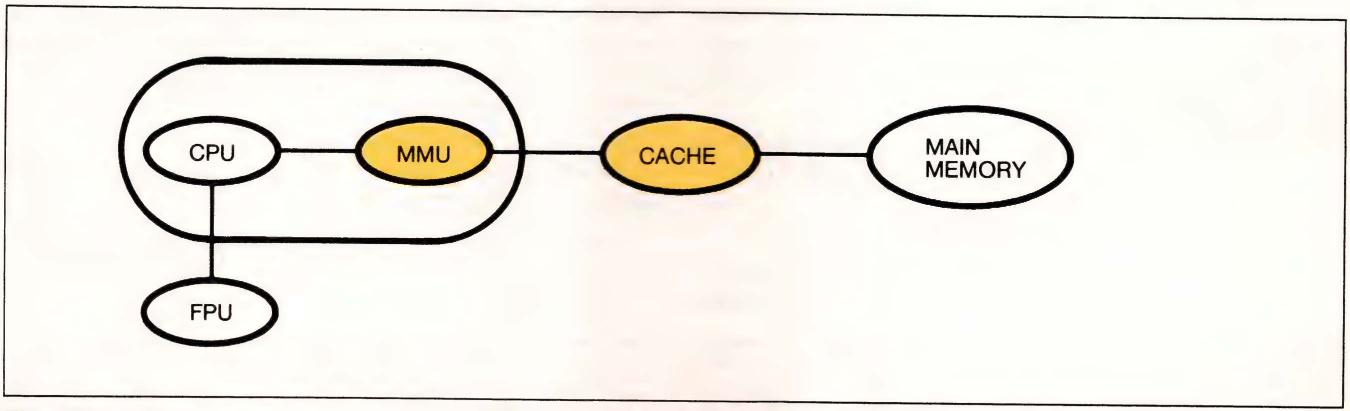


Fig 4—This 80386-based system *takes advantage of the chip's onboard MMU to pipeline accesses to the real cache.*

buffer characterized by a 30-nsec access time; the CPU accesses cache memory in 90 nsec. Main memory and disk memory have approximate access times of 500 nsec and 25 msec. The system's average total access time is a weighted sum of the average instruction-cache access time and the average data-cache access time. The average access time to main memory is less than 100 nsec when you use this cache design: a more than 5:1 reduction in access time.

Caches are real or virtual

One way to classify a cache is on the basis of whether it is real or virtual. If a cache resides between the CPU and MMU, then it's a virtual cache because it's accessed via virtual addresses. If the cache is located between the MMU and main memory, it's a real cache. A virtual cache has an advantage in that cache accesses don't incur MMU translation delays. A major drawback is that there isn't a 1:1 correspondence between virtual and real addresses; each cache address can be mapped into several main-memory addresses. This duplication complicates the task of the system programmer, and you may find it worthwhile to use a real cache in order to circumvent this added complication.

If you elect to design a real cache, you'll want to minimize MMU translation delays. One way is to translate only part of the virtual address, which is akin to memory paging. The MMU translates the upper-order address lines while the lower-order page-offset address goes directly into the cache. As long as the virtual address stays within the same page boundary, the total access time is limited to whichever takes longer, the MMU translation or the cache access. With this parallel access method, the only time your system suffers from the entire delay associated with a real cache is when the data is located in a page other than one that is mapped into the cache at the time of an attempted fetch.

No matter whether you choose to design a virtual or real cache, you also need to consider direct-mapped vs set-associative types. A direct-mapped cache provides just one storage location for a given location in main memory. The strength of this approach is its simplicity. A shortcoming is that any new data written into the cache will necessarily obliterate data already existing there. New data with the same cache offset as old data always replaces the old.

On the other hand, a set-associative cache reserves several storage locations for each location in main memory. When a new item of data is written into the cache, it need not replace data already residing in the cache if another compartment, or set, is available for storage. A set-associative cache is a type of content-addressable memory; a portion of the address, called a tag, is stored along with the data and determines which set the data belongs to. A set-associative cache requires a group of comparators (one for each set) to compare incoming address tags with those stored in the cache. A set-associative cache affords you more flexibility in implementing a data-replacement algorithm, and it accelerates data-fetch operations.

Whenever the CPU tries to access data not contained in the cache, the desired data must be swapped from

The basis for successful cache operation depends on locality of reference.

main memory into the cache, replacing data already residing there. The most straightforward method of cache replacement is a simple FIFO algorithm. Such an algorithm gets rid of the data that has resided in memory the longest, even if that data has been referenced on a consistent basis. Thus, data may be forced to continually swap in and out of main memory, reducing the effectiveness of the cache.

An alternative to the FIFO-replacement method is an LRU, or least recently used, algorithm. This replacement algorithm makes room in the cache by removing the data that hasn't been referenced lately. The LRU approach assumes that if a location has been accessed recently, it's likely to require access again in the near future. This assumption is valid; it is a direct outgrowth of the dual assumptions of temporal and spatial locality of reference upon which cache designs are built.

When the CPU operates on data in the cache, it must update the corresponding locations in main memory as well. One way to update main memory is through a technique known as write-through, whereby the CPU updates the cache and main memory on every write operation. A faster method is copy-back. The CPU only updates the main memory when it swaps a block of data between the cache and main memory. This technique can improve system performance by approximately 20% and is especially suited for procedural-oriented languages like C.

Glossary of cache terminology

Associative memory—Memory whose data the CPU locates on the basis of the memory's contents, not an address. The CPU compares a key in parallel with the corresponding lock (tag bits) of all the words stored in the memory. All memory locations whose tag bits match the key are available for CPU access.

Cache—A small, fast storage area interposed between the main memory and CPU to improve memory-transfer rates and processor efficiency. The name is derived from the fact that the memory is hidden from or transparent to the programmer.

Copy-back—A technique for reducing main-memory accesses by writing to data blocks in main memory only when those blocks are being swapped out of the cache.

Direct-mapped cache—A cache-mapping technique that assigns only one storage location in the cache for each location in main memory.

FIFO-replacement algorithm—When more storage area is needed, the data that has resided in the cache the longest moves out of the cache first.

Hit-rate—The probability, expressed as a percent, that a CPU will find the information it's searching for when it accesses a cache.

Locality of reference—The likelihood of finding data and instructions temporally or spatially close together in a computer program.

LRU-replacement algorithm—A method that's more effective than a FIFO-replacement approach. When more storage area is required, data in the cache is replaced in the order of the least recently used to the most recently used.

Real cache—A cache that's located between the memory management unit (MMU) and main memory. The MMU converts virtual addresses to real addresses before passing them on to the cache.

Set-associative cache—A cache-mapping technique where several storage locations are available in the cache for each location in the main memory.

Split cache—A cache that separates data and instructions.

Swapping—A transfer of data between cache and main memory. Due to the relatively small size of caches, a given data block may necessitate transfer back to main memory to make room for a block containing the data needed by the CPU.

Tag—That portion of an associative memory that the CPU compares with a key to determine which memory locations corresponding to words contained in the cache should be made available to the CPU for access.

Unified cache—A cache that stores both data and instructions for the CPU.

Virtual cache—A cache that resides between the CPU and MMU. Cache locations are accessed on the basis of virtual addresses from the CPU.

Write-through—A method that updates both the main memory and the cache on all write operations.

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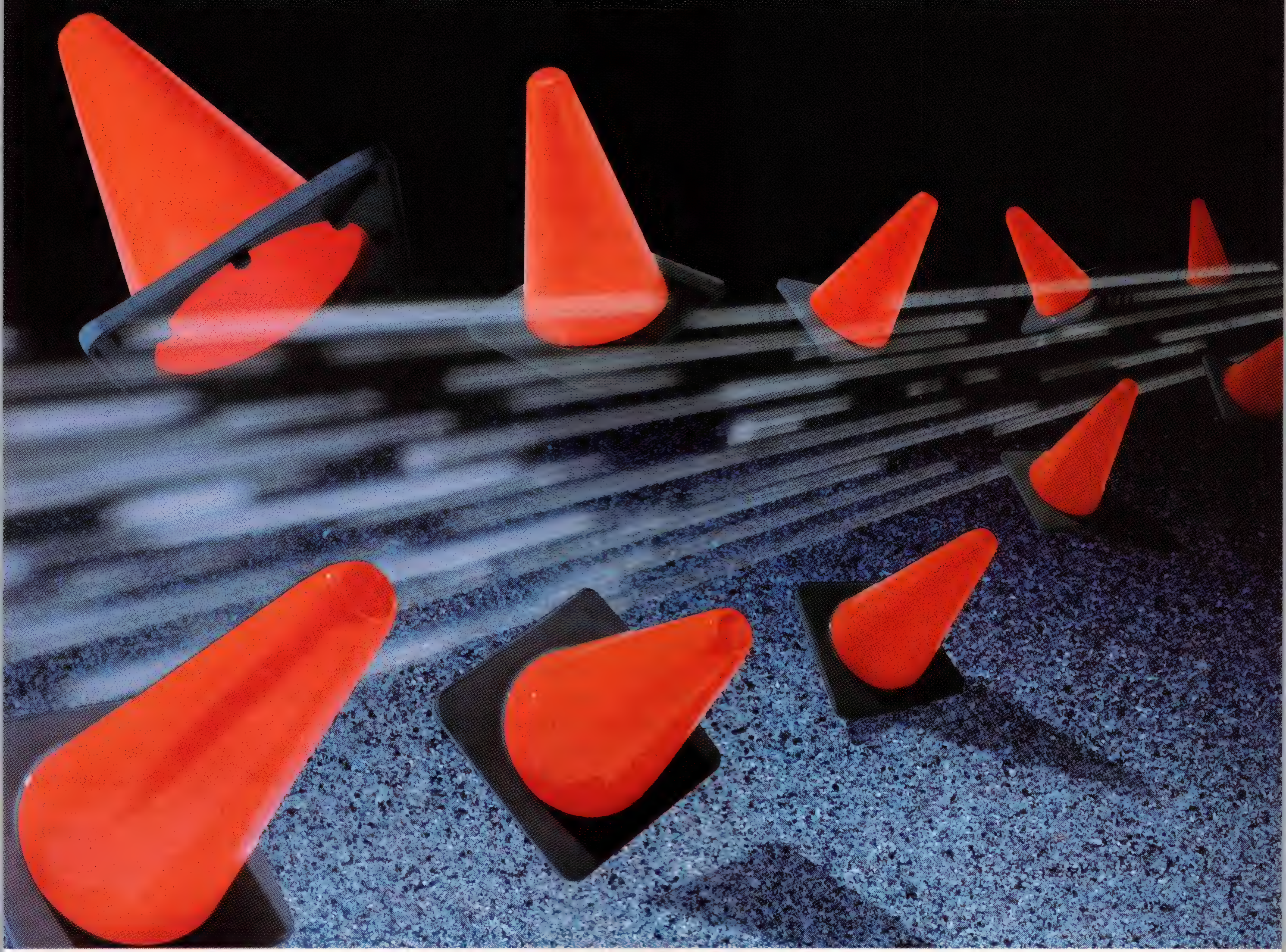

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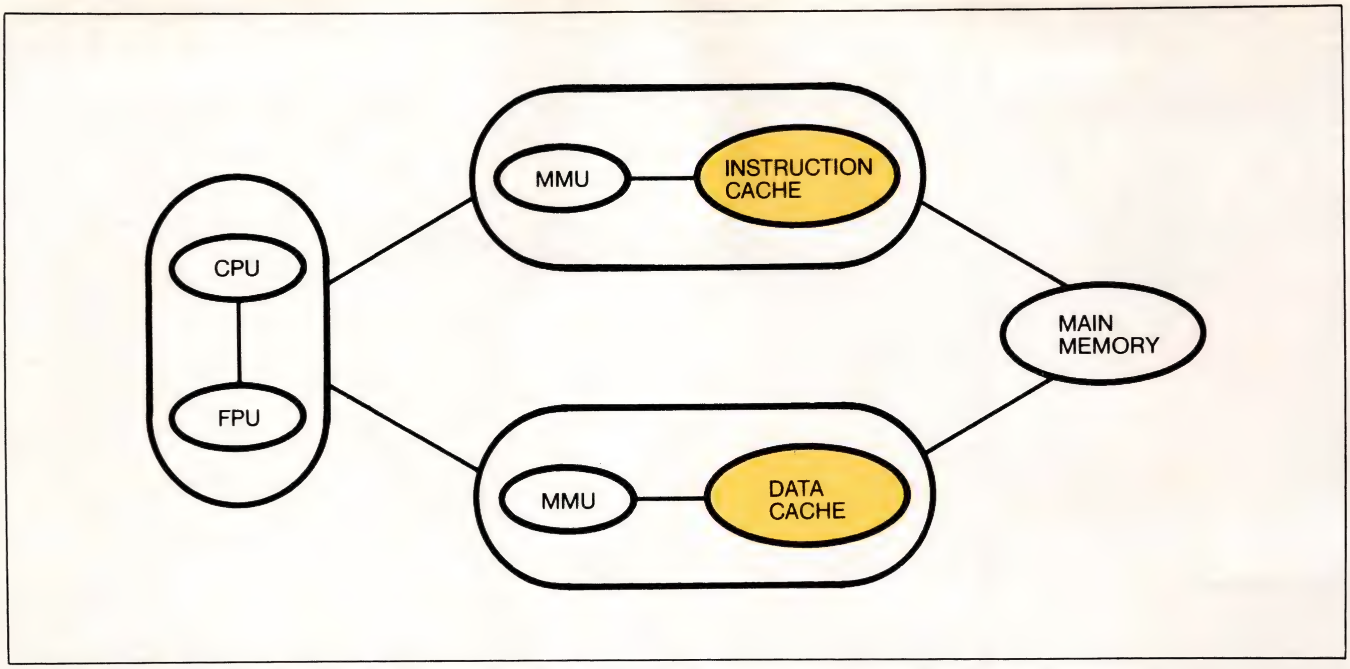


***Fig 5—This Clipper-based design** increases the bandwidth between the CPU and MMU by using a parallel split cache.*

Cache hit rates are a function of both the memory-mapping method and the amount of data transferred at a single access (line size or cache width). Associative caches provide better hit rates for a given size than direct-mapped types; wider lines allow more data transfer during each access, increasing the likelihood that the CPU will find the data it needs each time.

The curves of **Fig 2** illustrate hit-rate comparisons for four different line-size and mapping combinations. You can obtain the most dramatic increase in hit rate by increasing the line size from four to 16 bytes. As the curves show, a 2-way set-associative 16-byte-line cache achieves a hit rate of 90%; a 2-way set-associative cache with a 4-byte line achieves only a 70% hit rate.

Hardware support depends on manufacturer

Manufacturers of 32-bit processors have a number of ideas about how to design a cache into a system. **Figs 3, 4,** and **5** show three representative cache implementations. Each processor system contains the same five basic components (CPU, floating-point unit, MMU, cache, and main memory), but each system uses a cache in a different fashion.

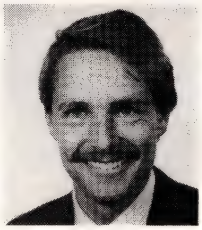
Fig 3 illustrates a cache implementation for the Motorola 68020 32-bit processor. In this 2-cache arrangement, one cache resides within the CPU chip to take advantage of higher-speed accesses. Because it's "on chip," however, its size is limited to 256 bytes, which decreases the probability of a hit. A larger cache resides off chip, downstream from the MMU.

Notice that this design includes both a virtual cache (the on-chip one) and a real cache (downstream from the MMU). As noted earlier, the main disadvantage with a real cache is that you are hampered by a translation delay each time the MMU translates a virtual address to a real address during cache accesses.

One solution for reducing this translation delay capitalizes on the on-chip pipelining provisions of the CPU. **Fig 4**'s design uses the pipelining capabilities of the Intel 80386 µP. The principle of locality of reference complements these pipelining capabilities and ensures an effective cache implementation.

Both of the foregoing examples are unified-cache implementations, but using a split-cache design may improve cache performance further. In **Fig 5,** the Fairchild Clipper processor supports parallel caches, one for data and one for instructions. Although the performance of this split-cache system suffers from a lower hit rate than the two unified-cache designs, the increased bandwidth (thanks to two 32-bit buses operating in parallel between the caches and the CPU) more than compensates for the lower hit rate. **EDN**

Author's biography



Robert Nalesnik is microprocessor marketing manager at Fairchild Europe Semiconductor in Wasserburg am Inn, West Germany, where he is responsible for all the company's microprocessor marketing activities in Europe. He received his BSEE from the Georgia Institute of Technology and lists skiing, rock climbing, and windsurfing as his favorite pastimes.

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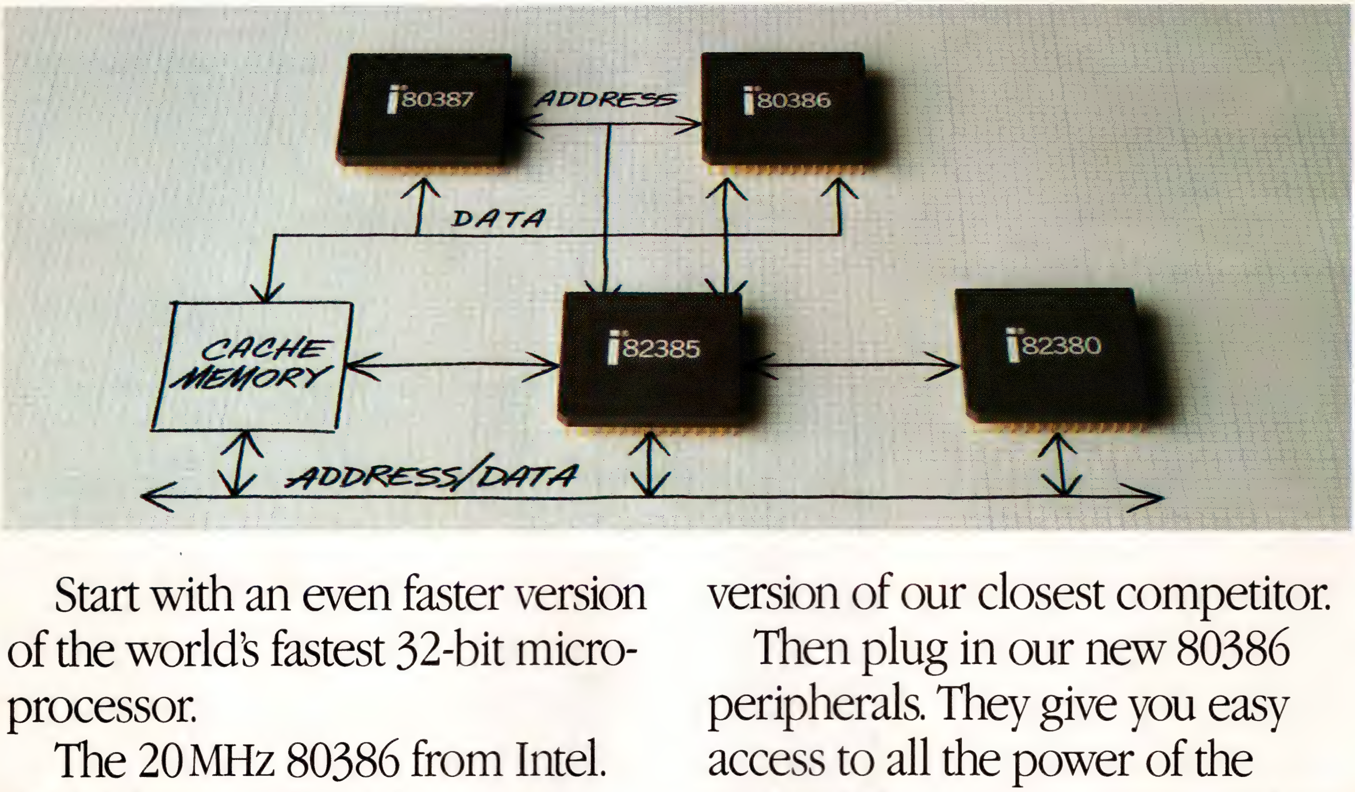

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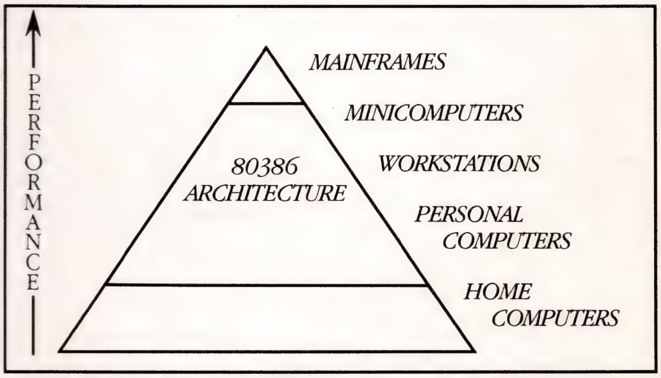

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Shift-register applications reach gigahertz range

Applications that employ shift registers would hardly turn their backs on higher-speed devices, and GaAs-based parts that can achieve gigahertz clock rates are starting to appear. When those parts incorporate an on-chip XNOR gate for pseudorandom-number generation, they extend the range of shift-register applications.

Panos Argyroudis and John Schaefer,
GigaBit Logic

Computational applications of high-speed registers—such as cache memories, digital RF memories, pipeline-processor systems, modulo-N counters, and state machines—stand to benefit greatly from the introduction of parts that can attain gigahertz clock rates. When such registers have the ability to generate pseudorandom-number codes as well, applications that require the generation of long patterns of random words at very high speeds—such as in-house test instrumentation and communications scrambling—join the list of viable shift-register uses. Gallium-arsenide processing and on-chip XNOR gates are the keys to these improvements in shift-register performance.

One chip that meets the needs of these applications is the 10G022, which can operate as a serial or parallel register. Manufactured with a GaAs process technology and featuring a worst-case propagation delay of 950 psec, the 10G022 delivers three to four times the speed of ECL parts performing comparable functions at equivalent power levels. It can achieve a clock frequency of 1.5 GHz as a parallel register, 1.5 GHz as a shift register, and 1.1 GHz as a pseudorandom-number (P/N) code generator. Its output rise and fall times are typically 150 psec.

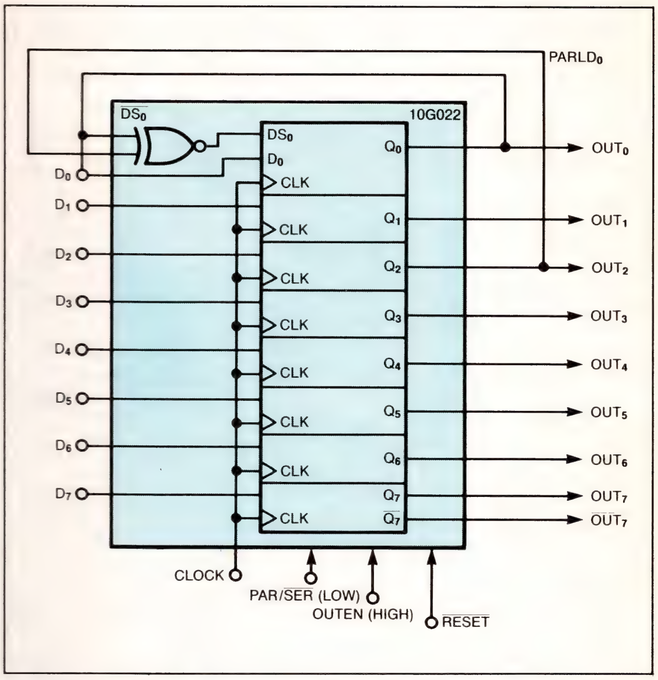


***Fig 1—You set up the 10G022 as a P/N-code generator** by connecting the two inputs of the XNOR gate to any of the outputs of the register to generate the desired random pattern.*

Traditionally, you would use 300-MHz ECL shift registers and external XOR gates to generate P/N codes. What's notable about the 10G022's architecture is its inclusion of an on-chip XNOR gate, which elimi-

Applications of GaAs shift registers include instrumentation, communications, scrambling and descrambling, modulo-N counters, and cache memories.

nates the usual external delay, to generate the P/N codes. Also, replacing the 300-MHz ECL parts with a 1.5- to 1.8-GHz shift register effects a three- to fourfold improvement in speed.

To operate the register in the P/N-code-generator mode, you connect the $\overline{DS_0}$ input to D_0 and hold the PAR/$\overline{SER}$ pin low and the OUTEN pin high **(Fig 1).** You can connect the two inputs of the XNOR gate ($\overline{DS_0}$ and $PARLD_0$) to any of the outputs of the register (Q_0 to Q_7) to generate the desired random pattern. Your choice of outputs, or taps, determines the length of the code; **Table 1** shows several examples of pseudorandom sequences and the corresponding taps using the 10G022. Because the 10G022 departs from the traditional XOR implementation, the resulting codes will vary from the traditional tables generated from XOR gates.

A P/N code consists of a stream of high and low

TABLE 1—REPRESENTATIVE P/N-CODE LENGTHS AND ASSOCIATED 10G022 TAPS

TAPS	SEQUENCE LENGTH
Q_0 Q_1	3
Q_0 Q_2	7
Q_1 Q_2	7
Q_0 Q_3	15
Q_2 Q_3	15
Q_1 Q_4	31
Q_2 Q_4	31
Q_0 Q_5	63
Q_4 Q_5	63
Q_0 Q_6	127
Q_2 Q_6	127
Q_3 Q_6	127
Q_5 Q_6	127

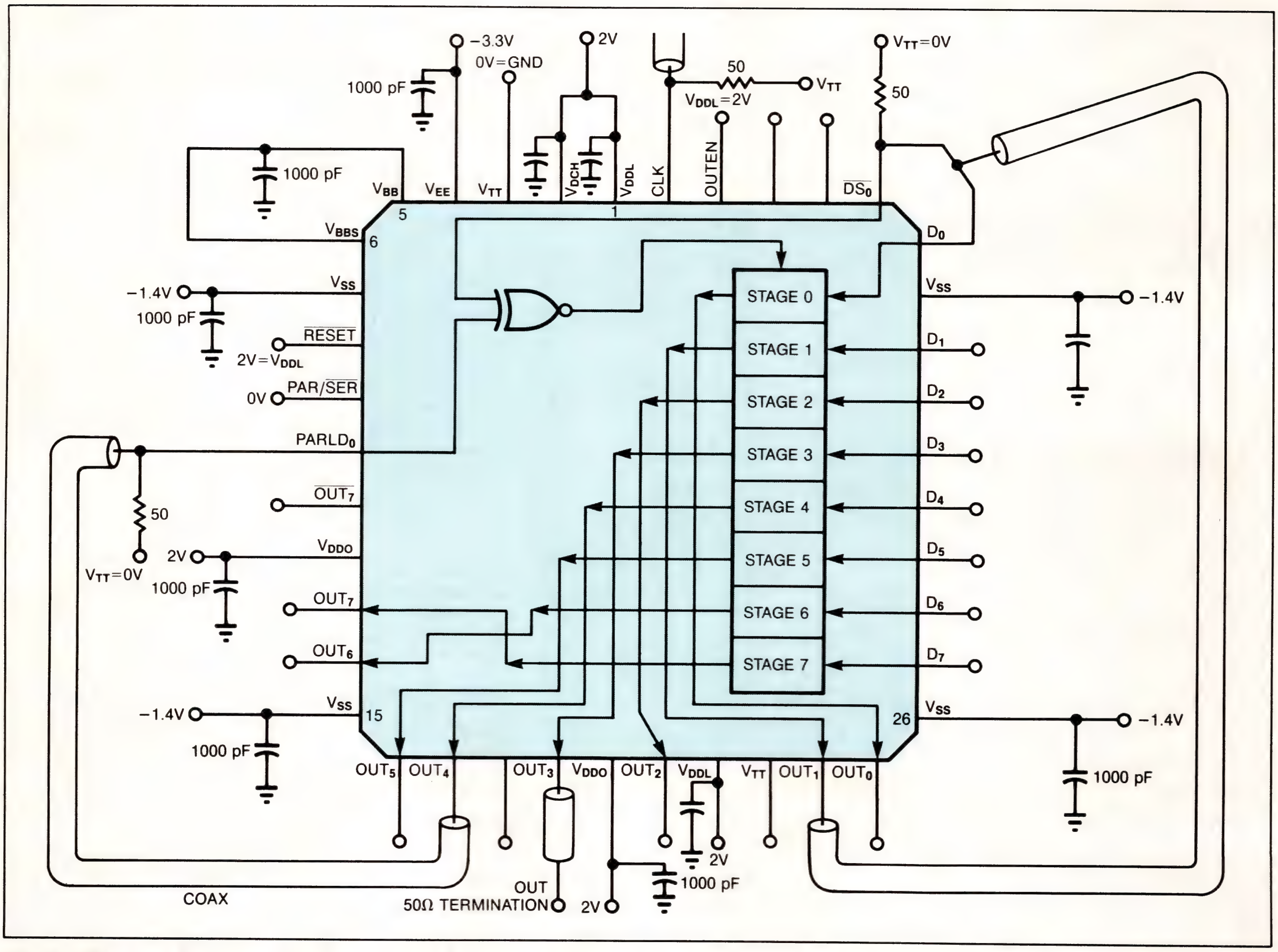


Fig 2—When you designate pins Q_1 and Q_4 as the feedback taps, the 10G022 generates a 31-bit maximal-length code.

signals generated in a random order. An important characteristic of a P/N signal is the number of bits (1 bit=1 clock period) after which the entire random pattern repeats itself. Longer pseudorandom patterns have less periodicity and are therefore more random. Another important characteristic is the data rate at which the device can generate P/N patterns: the higher the data rate, the more repetitions of patterns you can fit into a given period. Because the 10G022 operates at high data rates, you can satisfy requirements for longer codes by cascading devices.

A P/N-code-generation circuit using the 10G022 configured with feedback taps from Q_1 and Q_4 (stages 1 and 4 in **Fig 2**) generates a 31-bit maximal-length code. **Trace A** in the output waveform of **Fig 3** shows a section of this random pattern (**Trace B** is the clock signal). At a nominal clock frequency of 1.1 GHz, the 31-bit P/N code will repeat in 28.2 nsec (T=31×1/1.1 GHz).

This circuit uses only the first five stages of the shift register to generate 31 of the 32 possible states. Codes that cycle through 2^n-1 states are known as maximal-length codes. In this case n=5, where "n" represents the number of register stages used. For n=5 stages, and with taps at Q_1 and Q_4, the resulting 31-bit pattern is

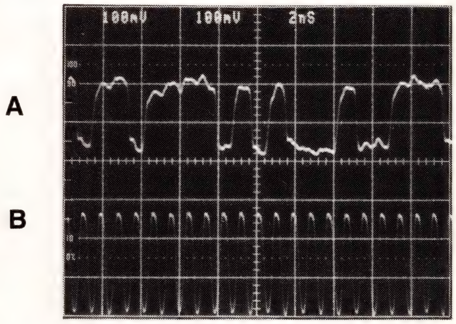
1100101101111010100010011100000.

The one state that's not part of the generated code occurs when $Q_0Q_1Q_2Q_3Q_4=11111$. If such a state appears on the register, the code locks into this state, which is called the "persistent," or "locking," state. If you apply a reset signal while the register is in the persistent state, the code generation will resume.

The sequences discussed in this example are maximal-length sequences, but you may have occasion to use codes that are not maximal length. In a nonmaximal-length sequence, the number of unwanted states (or states that do not belong to the main loop) is greater than one.

A routine written in Basic, called PNCODE, greatly facilitates the selection of feedback taps. This interactive routine accepts two candidate feedback taps and provides the following information to help you refine your choice:

- It identifies the cycle of states starting from the clear condition.
- It notifies you whether or not the code is maximal length.



TRACE	VERTICAL	HORIZONTAL
A	100 mV/DIV	2 nSEC/DIV
B	100 mV/DIV	2 nSEC/DIV

*Fig 3—**This waveform shows part of the 31-bit P/N code** generated by the **Fig 2** circuit. At a nominal clock frequency of 1.1 GHz, the code sequence repeats approximately every 28 nsec.*

TABLE 2—SAMPLE PNCODE OUTPUT

```
TAPS USED FROM STAGES 1 AND 5
THE TABLE BELOW CONTAINS ALL ACTIVE STATES FOR THIS CODE

0  0  0  0  0
1  0  0  0  0
0  1  0  0  0
1  0  1  0  0
0  1  0  1  0
1  0  1  0  1
1  1  0  1  0
0  1  1  0  1
0  0  1  1  0
1  0  0  1  1
1  1  0  0  1
1  1  1  0  0
0  1  1  1  0
1  0  1  1  1
1  1  0  1  1
1  1  1  0  1
1  1  1  1  0
0  1  1  1  1
0  0  1  1  1
0  0  0  1  1
0  0  0  0  1
TOTAL NUMBER OF STATES FOR THIS CODE = 21
MAXIMUM FEASIBLE STATES = 32
THE CODE GENERATED IS NOT A MAXIMAL LENGTH

THE TABLE BELOW CONTAINS THE NON-PARTICIPANT STATES

1  1  0  0  0
0  0  1  0  0
0  1  1  0  0
0  0  0  1  0
1  0  0  1  0
1  0  1  1  0
1  0  0  0  1
0  1  0  0  1
0  0  1  0  1
0  1  0  1  1
1  1  1  1  1
THERE IS A LOCK UP CONDITION IF THE STARTING STATE IS DECIMAL 3

SEQUENCE OF STATES STARTING FROM FORBIDDEN STATE 3

1  1  0  0  0
0  1  1  0  0
1  0  1  1  0
0  1  0  1  1
0  0  1  0  1
0  0  0  1  0
1  0  0  0  1
THERE IS A LOCK UP CONDITION IF THE STARTING STATE IS DECIMAL 4
```

By combining the functions of a shift register and an XNOR gate, a GaAs device can generate long pseudorandom-number codes at speeds above 1 GHz.

- It lists all unwanted states.
- It produces the cycle of states for each of the unwanted states.
- It warns the user of a possible lockup condition in each case.

Table 2 gives an example of an output that you would see if you used the program. (A complete listing of the PNCODE program is available from GigaBit Logic, 1908 Oak Terrace Lane, Newbury Park, CA 91320.)

In the instrumentation field, the generation of high-speed test vectors at 100-MHz clock rates is difficult, and at gigahertz clock rates, it's next to impossible. Commercial word generators capable of such speeds are not available. Typically, users develop a variety of in-house systems based on commonly available signal generators, sampling scopes, and high-speed test fixtures. One high-speed technique successfully used in data-transmission systems is the measurement of the bit error rate (BER) when the device under test (DUT) is driven with a pseudorandom digital stream. Pseudorandom streams are particularly useful in identifying any pattern sensitivities exhibited by a device or system. Accordingly, they serve as a worst-case high-speed performance test.

Fig 4 shows a simplified diagram of such a BER tester based on the 10G022 and other parts in the same family. The transmitter section is a 10G022 that generates a 127-bit-long (2^7-1 bits) P/N code. The receiver section replicates this P/N sequence for comparison purposes. To achieve automatic synchronization between the two sections, you preload the receiver's P/N-code generator with an initial state (for example, all zeros) and keep the generator initially unclocked (that is, have the clock gate shut the clock off). An additional 10G022 serially shifts in the received data for comparison purposes. When the received word matches the preloaded word, as flagged by a 10G045 (used as an equivalence checker), the gate starts the clock. The circuit then compares the receiver's P/N sequence with the received digital word through a 10G002 XOR/XNOR gate. An error counter subsequently monitors the output of this gate.

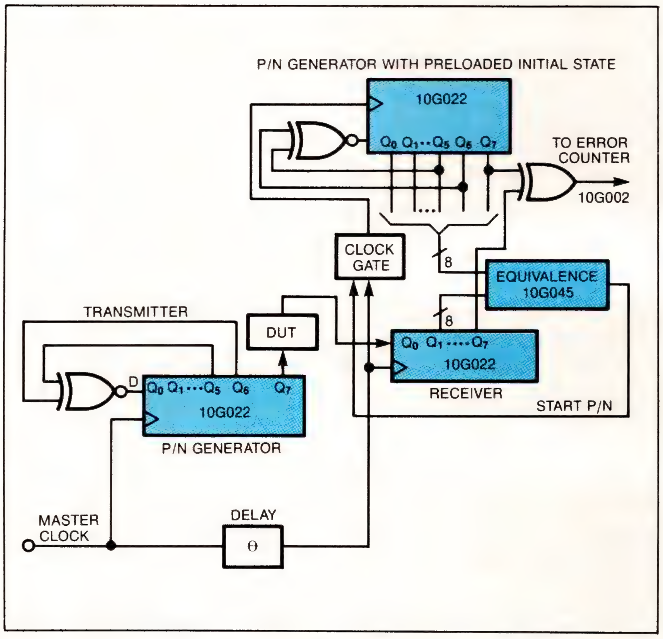


Fig 4—In this bit-error-rate tester, *the 10G022 transmitter generates a 127-bit P/N code, which is replicated in the receiver section for comparison.*

High-speed digital serial communication, especially over a fiber-optic medium, is a definite application domain for GaAs ICs. As transmission clock rates become higher and higher—reaching even to the gigahertz realm—GaAs ICs fulfill the requirements for the

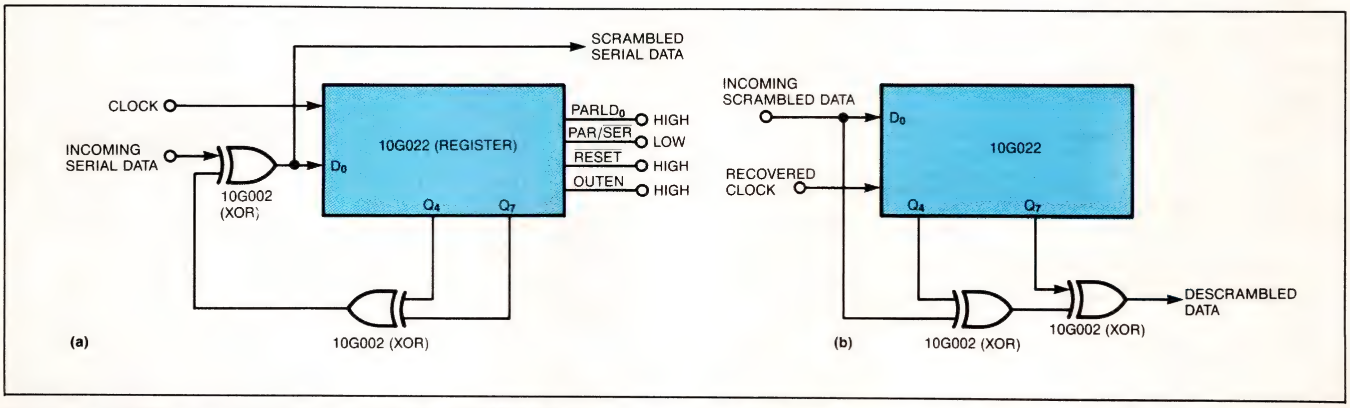


Fig 5—A 10G022 serial register and 10G002 XOR/XNOR gates *can serve as a high-speed scrambler* ***(a)*** *and descrambler* ***(b).*** *Such circuits are useful in high-speed synchronous digital communication—particularly those that employ a fiber-optic medium.*

TABLE 3—STATE DIAGRAM FOR A MODULO-10 COUNTER

	State	Q_0	Q_1	Q_2	Q_3
	0	0	0	0	0
REQUIRED	1	1	0	0	0
JUMP FOR	2	0	1	0	0
MODULO-10	5	1	0	1	0
OPERATION	10	0	1	0	1
	4	0	0	1	0
	9	1	0	0	1
	3	1	1	0	0
	6	0	1	1	0
	13	1	0	1	1
	11	1	1	0	1
	7	1	1	1	0
	15	1	1	1	1
	14	0	1	1	1
	12	0	0	1	1
	8	0	0	0	1

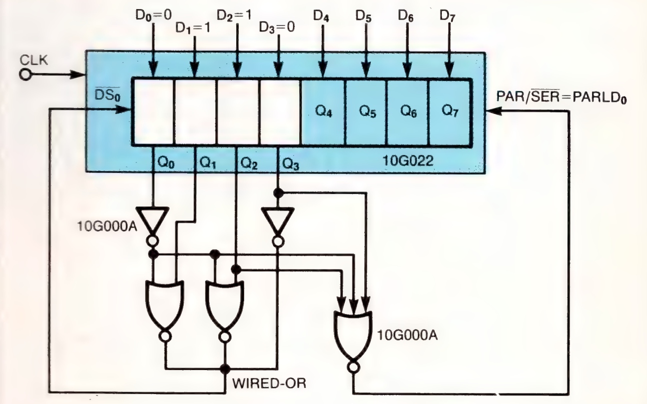


***Fig 6—This modulo-10 counter cycles through ten states,** and only four of the eight 10G022 register stages are needed; the values of D_0 through D_3 reflect the parallel loading of state 6. **Table 3** shows the state diagram for this counter, and **Table 4** illustrates the use of Karnaugh maps in deriving the feedback loops.*

scramblers and descramblers used to encode the transmissions.

Synchronous digital communication transmitters often use scramblers to randomize the data, thus rendering them secure. Descramblers located at the receiving end descramble the incoming serial data stream before any processing takes place. You can use the 10G022 serial register and the 10G002 XOR/XNOR gate to build a high-speed scrambler **(Fig 5a)** and a descrambler **(Fig 5b)**.

The standard techniques for using shift registers to build modulo-N counters, or state machines in general, are well known, but GaAs devices add another dimension. The high-speed 10G022 shift register and other parts in the same family allow these applications to operate at gigahertz clock rates. You can use the 10G022 to design all the standard counting modes, as well as the difficult divide/count functions. You can, for example, connect the 10G022 to divide by any modulo as high as 256—a feature that's particularly useful in frequency-synthesis applications.

To design a modulo-N counter based on the 10G022, you essentially follow a 3-part procedure:

- Select the basic state diagram for the particular modulo-N counter.
- Generate the feedback logic.
- Make sure that unused states don't cause lockup.

As an example, consider a modulo-10 counter, which cycles through ten states. Only four of the eight stages of the register are required for this operation. **Table 3** shows the state diagram for the shift register; the diagram gives the cycle through all 16 states. The jump arrow indicates the point in the cycle where the operation of the register changes from serial shifting to parallel loading of state 6. **Fig 6** shows a 10G022 configured as just such a counter; the values given for D_0 through D_3 are the values associated with state 6.

The counter requires two types of feedback circuitry: one to feed the serial input ($\overline{DS_0}$), and the other to control the parallel/serial operation through the $PARLD_0$ and PAR/$\overline{SER}$ inputs. The Karnaugh maps of **Table 4** provide the means for deriving these two feedback loops.

To fill the Karnaugh maps you must examine the state diagram and determine the column entries. For example, the initial state (state 0) requires that the data be a "1"; the entry at $Q_0Q_1Q_2Q_3$=0000 will be "0" because $\overline{DS_0}$ is the inverted serial input. The transition from state 0 to state 1 effects a change in operation from serial mode to parallel mode; the entry for state 1 ($Q_0Q_1Q_2Q_3$=1000) is therefore "1" (the data is no longer inverted). After the jump to state 6 ($Q_0Q_1Q_2Q_3$=0110), the operation returns to serial mode, and the appropriate entry is "0". The "X" entries represent all the states omitted because of the parallel loading.

One of the primary applications for a register is fast temporary storage in pipelined systems. In general, a pipeline system consists of a series of processing segments through which the information stream passes. Each segment of the pipeline includes a processing element and a holding register **(Fig 7)**.

In general, a pipeline processor employs two types of pipeline. The instruction pipeline is responsible for processing the instruction cycle of the CPU, while the arithmetic pipeline handles all complex arithmetic operations. Pipelined floating-point adders and multipliers, as well as entire arithmetic units, are not uncommon.

The 10G022, with its subnanosecond output delays, minimal skews, and 1.5-GHz max clock operation (in parallel I/O mode), is an excellent candidate for a pipelined system. When you use the GaAs 10G022 with parts fabricated in other technologies, such as ECL, its contribution appears as a negligible delay in the opera-

Generating test vectors at clock rates over 100 MHz is difficult. A high-speed technique measures the bit error rate when driven with a pseudorandom digital stream.

TABLE 4—KARNAUGH MAPS FOR DERIVATION OF FEEDBACK LOOPS

$\overline{DS_0}$
(SERIAL MODE)

	Q_2Q_3	00	01	11	10
Q_0Q_1	00	0	1	1	X
	01	X	X	1	0
	11	X	0	1	0
	10	X	X	0	X

$$\overline{DS_0} = \overline{\overline{Q}_3 + Q_0 Q_1 + Q_0 \overline{Q}_2} = \overline{\overline{Q}_3 + (Q_0 + Q_1) + \overline{Q}_0 + Q_2)}$$

(NOR IMPLEMENTATION)

$PARLD_0 = PAR/\overline{SER}$
(PARALLEL MODE)

	Q_2Q_3	00	01	11	10
Q_0Q_1	00	0	0	0	X
	01	X	X	0	0
	11	X	0	0	0
	10	1	X	0	X

$$PARLD_0 = PAR/\overline{SER} = Q_0 \overline{Q}_2 \overline{Q}_3 = \overline{\overline{Q}_0 + Q_2 + Q_3}$$

(NOR IMPLEMENTATION)

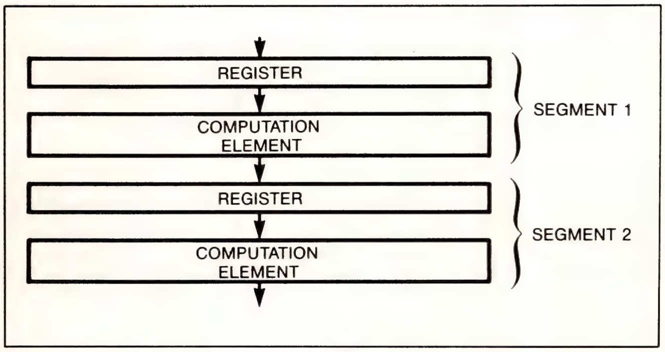


Fig 7—Each segment of the pipeline in a pipeline-processing system *contains two elements: a processing element and a holding register.*

tion of the overall system.

One common application of pipeline registers is in cache memories. A cache memory acts as a buffer for slower memories in the system by taking a segment of memory and making it accessible at the full execution speed. Typically, complex computational systems such as supercomputers or superminicomputers use cache memory to achieve the fastest possible system performance. The majority of existing mini- and supercomputer designs employ ECL technology, but by replacing ECL processors and memories with GaAs versions, you can effect immediate improvements in performance. Cache cycle times under 5 nsec are now possible.

One more area that holds great promise for GaAs shift registers is high-speed digital RF memories (DRFM), commonly used in electronic warfare (EW) systems. Currently, the central core circuitry of the DRFM depends upon a combination of microwave analog and ECL digital components, and one of the major factors limiting the performance of DRFMs is the slower (300 to 400 MHz) ECL components. The emergence of 1- to 2-GHz GaAs digital ICs opens the door to the replacement of ECL and memory with devices offering a three- to fivefold improvement in performance. **EDN**

Authors' biographies

Panos Argyroudis is a design engineer at GigaBit Logic (Newbury Park, CA), where he is responsible for the logic and circuit design of GaAs ICs. Prior to joining the company three years ago, he was with Litton Data Systems (Van Nuys, CA). He has a degree in electronic engineering from the University of Patras in Greece. His hobbies include fishing, jogging, and swimming.

Since contributing to this article, John Schaefer has joined Plessey Semiconductor (Irvine, CA). As a strategic marketing manager for GigaBit Logic, he was responsible for the formation of product-line strategies, new-product definition, and all phases of product marketing. Previously he was with Fairchild Camera and Instrument Corp for six years, serving in various marketing capacities. He has a BSEE from the University of Utah. In his spare time, he enjoys skiing, golfing, and photography.

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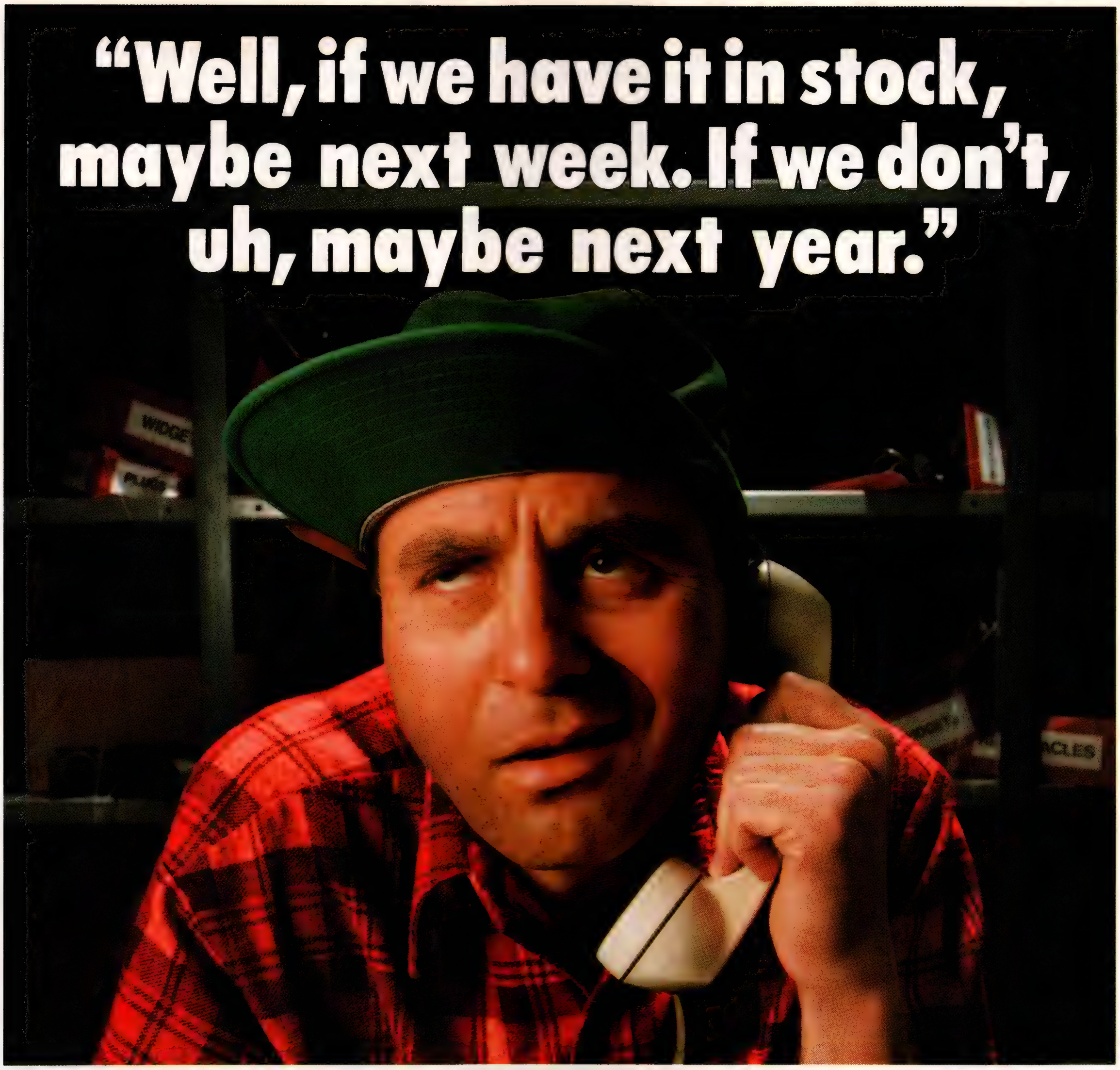
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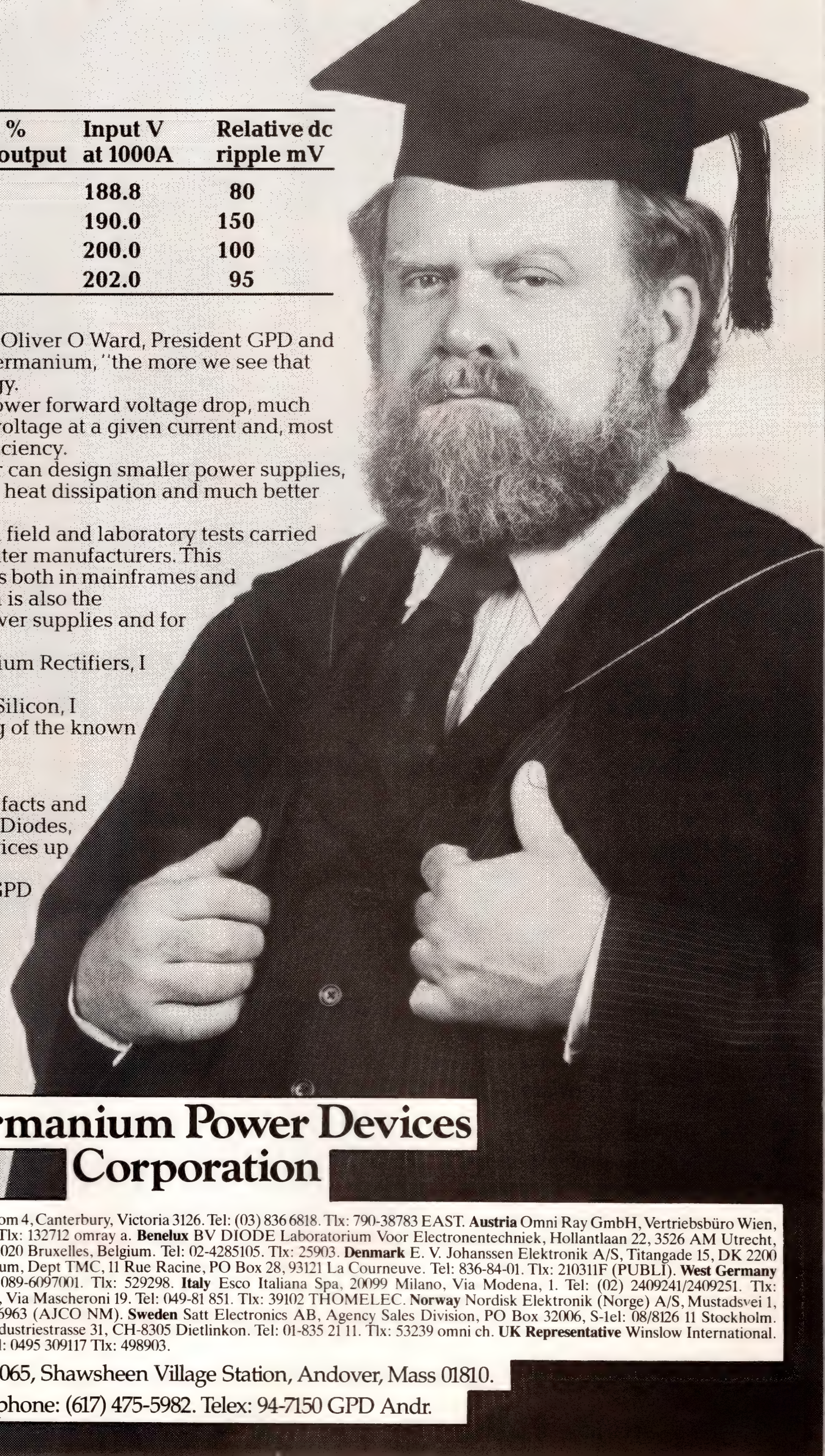
Silicon A	**1.20**	**76.0**	**200.0**	**100**
Silicon B	**1.25**	**74.0**	**202.0**	**95**



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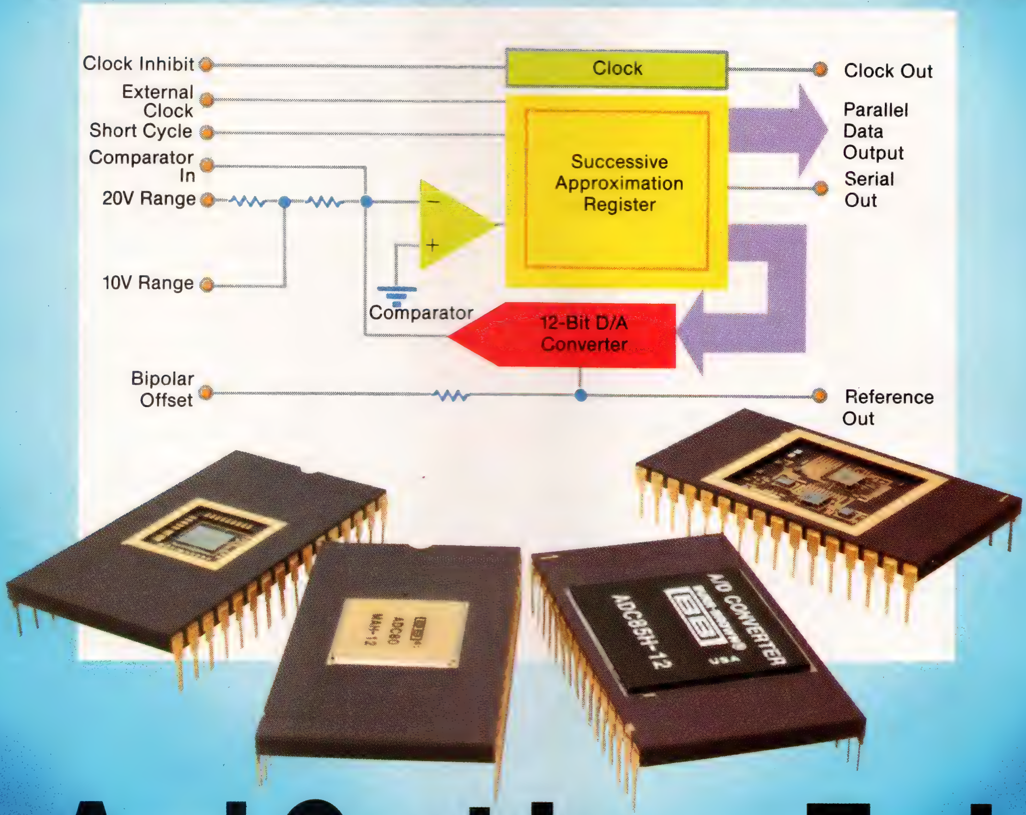

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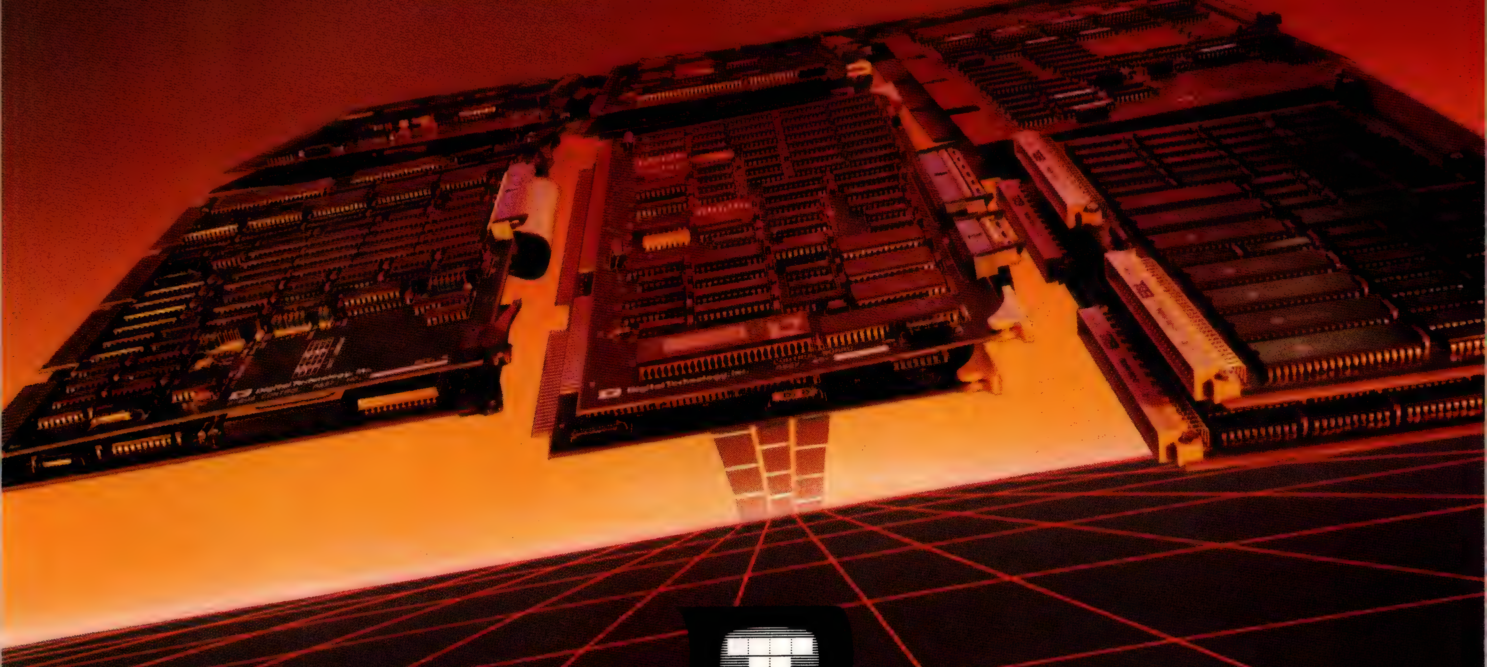

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CIRCLE NO 117

XOR PLDs simplify design of counters and other devices

XOR PLDs' unique architecture is better suited than that of conventional AND-OR PLDs to certain applications. Once you understand the basic theory behind their operation, you can easily configure them to perform the tasks of such devices as binary counters and video shift registers.

Chris Jay, *Monolithic Memories Inc*

Many designs—notably high-speed counters for accessing memories, for counting events, or for sequential control in high-speed processor systems—require state machines that step through their sequence of operation by a binary count. XOR PLDs are ideal devices for these types of jobs, but they are rarely considered for such applications—perhaps because design engineers don't understand their useful, but unusual, architecture.

Like the more sophisticated of today's conventional devices (**Fig 1a**), exclusive-OR (XOR) versions have a registered architecture (**Fig 1b**). The distinguishing features of the latter are two pairs of product terms (multiple-input AND gates), which drive two summing terms (OR gates), which in turn feed two inputs of an XOR gate. The combinational XOR gate's output connects directly to the D input of the register. (For a theoretical discussion of the advantages of XOR PLDs over AND-OR PLDs, see **box**, "Principles of XOR PLD operation.")

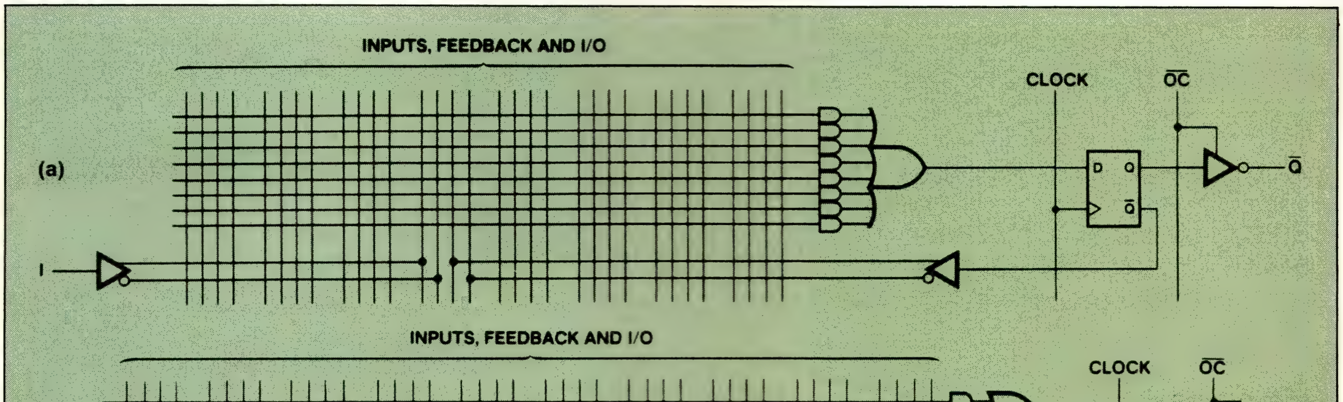

***Fig 1—You can easily distinguish between a conventional AND-OR PLD (a)** and an XOR PLD **(b)**. The latter has an XOR gate preceding the register.*

The distinguishing features of an XOR PLD are two pairs of product terms, which drive two summing terms, which in turn feed two inputs of an XOR gate.

The applications described here make use of MMI's 20X8A and 20X10A PAL devices. These 24-pin XOR PLDs have an improved 22.2-MHz clock and worst-case propagation delay of 30 nsec compared with older, 12.5-MHz, 50-nsec parts.

XOR PLDs bring benefits to counters

The prime use of XOR PLDs is in counters. **Fig 2a** shows the pinouts and **Fig 2b** the Palasm logic equations of a 10-bit, loadable, up/down counter. You can design such a counter into a single 20X10A PAL device. The counter has ten registers, Q0 through Q9, capable of binary, up/down counting. The up control is high for an up count and low for a down count. Registers Q1 through Q8 load synchronously through data inputs D1 through D8; the loading is enabled by an active-low /LD input (see **box,** "Palasm notational conventions"). Because of a pin limitation of the package, Q9 loads via the up/down-control pin. This pin (the D9 input during loading) controls the counter's up- or down-counting mode. Q0 is always loaded with a logic low.

A counter larger than 10 bits requires two or more XOR PLDs. Unlike MSI counters, which come with carry-in and carry-out pins, you must incorporate in your design provisions for cascading XOR PLDs. When cascading two XOR PLDs, you must provide a carry-out-enable signal from the least significant counter to the count-enable input of the most significant counter.

When the least significant counter has reached its maximum count, it should enable the most significant counter to increment its count after the next rising edge of the clock pulse. However, time delays arising from the time needed to decode and propagate the Carry signal could slow the system down. To avoid this delay, your design should generate a look-ahead-carry output.

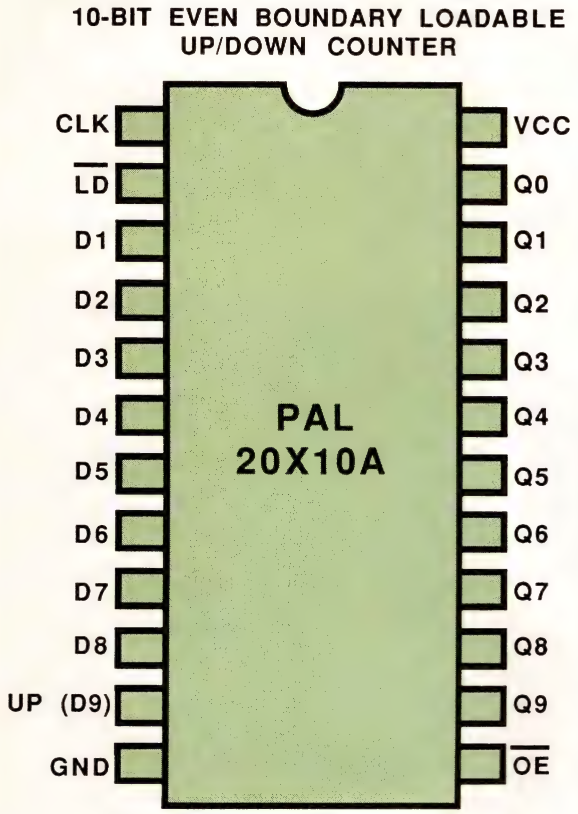

Fig 2b

```
/Q0 :=   Q0*/LD                                      ;COUNT
         + LD                                        ;LOAD
         :+: GND + GND                               ;

/Q1 :=  /Q1*/LD                                      ;HOLD
        + /D1*LD                                     ;LOAD
        :+: Q0*/LD*UP                                ;COUNT UP
        + /Q0*/LD*/UP                                ;COUNT DOWN

/Q2 :=  /Q2*/LD                                      ;HOLD
        + /D2*LD                                     ;LOAD
        :+: Q0*Q1*/LD*UP                             ;COUNT UP
        + /Q0*/Q1*/LD*/UP                            ;COUNT DOWN

/Q3 :=  /Q3*/LD                                      ;HOLD
        + /D3*LD                                     ;LOAD
        :+: Q0*Q1*Q2*/LD*UP                          ;COUNT UP
        + /Q0*/Q1*/Q2*/LD*/UP                        ;COUNT DOWN

/Q4 :=  /Q4*/LD                                      ;HOLD
        + /D4*LD                                     ;LOAD
        :+: Q0*Q1*Q2*Q3*/LD*UP                       ;COUNT UP
        + /Q0*/Q1*/Q2*/Q3*/LD*/UP                    ;COUNT DOWN

/Q5 :=  /Q5*/LD                                      ;HOLD
        + /D5*LD                                     ;LOAD
        :+: Q0*Q1*Q2*Q3*Q4*/LD*UP                    ;COUNT UP
        + /Q0*/Q1*/Q2*/Q3*/Q4*/LD*/UP                ;COUNT DOWN

/Q6 :=  /Q6*/LD                                      ;HOLD
        + /D6*LD                                     ;LOAD
        :+: Q0*Q1*Q2*Q3*Q4*Q5*/LD*UP                 ;COUNT UP
        + /Q0*/Q1*/Q2*/Q3*/Q4*/Q5*/LD*/UP            ;COUNT DOWN

/Q7 :=  /Q7*/LD                                      ;HOLD
        + /D7*LD                                     ;LOAD
        :+: Q0*Q1*Q2*Q3*Q4*Q5*Q6*/LD*UP              ;COUNT UP
        + /Q0*/Q1*/Q2*/Q3*/Q4*/Q5*/Q6*/LD*/UP        ;COUNT DOWN

/Q8 :=  /Q8*/LD                                      ;HOLD
        + /D8*LD                                     ;LOAD
        :+: Q0*Q1*Q2*Q3*Q4*Q5*Q6*Q7*/LD*UP           ;COUNT UP
        + /Q0*/Q1*/Q2*/Q3*/Q4*/Q5*/Q6*/Q7*/LD*/UP    ;COUNT DOWN

/Q9 :=  /Q9*/LD                                      ;HOLD
        + /UP*LD                                     ;LOAD
        :+: Q0*Q1*Q2*Q3*Q4*Q5*Q6*Q7*Q8*/LD*UP        ;COUNT UP
        + /Q0*/Q1*/Q2*/Q3*/Q4*/Q5*/Q6*/Q7*/Q8*/LD*/UP ;COUNT DOWN
```

Fig 2a—This diagram shows the pin designations *for a 20X10A XOR PLD configured as a 10-bit, loadable, up/down counter. This design is not cascadable.*

Principles of XOR PLD operation

The configuration of an exclusive-OR (XOR) PLD simplifies counters and other state machines that progress through a binary-encoded counting sequence. You do not, of course, necessarily need a PLD with XOR gates to design a binary counter; you can use the simpler, sum-of-products (SOP) architecture of a conventional PLD (see **Fig 1a** in the main text) to implement the logic equations that define a binary-count sequence.

However, the conventional PLD requires a larger number of AND gates, or product terms, for a counter's higher-order registers than does an XOR PLD. The Boolean equations that follow prove this point. They are required for a generalized binary-count sequence and are rendered in Palasm notation (see **box,** "Palasm notation conventions").

If Q0 is the least significant register, then

/Q0 := Q0

This is a straightforward binary function—divide by 2. If Q1 is the next significant register, it requires the Boolean sum of two product terms:

/Q1 := Q0*Q1 + /Q0*/Q1

For register Q2 the equation becomes

/Q2 := Q2*Q1*Q0 + /Q2*/Q1 +
/Q2*/Q0

which requires three product terms. For a generalized counter with N registers, the Nth register, QN, requires N+1 product terms:

/QN := QN*Q(N−1)* . . . Q1*Q0
+ /QN*/Q(N−1)
. . .
+ /QN*/Q1
+ /QN*/Q0

For example, the most significant register in a 10-bit counter, Q9, would require the summing of 10 product terms, using 10 AND gates, in a conventional AND-OR PLD. Consequently, although you can write abstract counter equations for AND-OR PLDs, you may not be able to find a real PLD with enough product terms to embody those equations.

An XOR PLD, on the other hand, uses its product terms more economically; no matter how significant the weighting of the register in a binary counter, each register requires only two product terms.

Before delving into the detailed Boolean equations that support the preceding contention, you should get a feel for the logic underlying the XOR PLD. Consider that, in a binary-count sequence, the polarity of a register's output toggles one clock period after the state in which all of the less significant registers were a logic one.

Next, imagine that you have a 2-input XOR gate driving a register. The output of the register is fed back to one XOR input; the other input sees a product term comprising all the less-significant digits. The XOR gate will hold the register in its existing state until the product terms of the less-significant digits go True, whereupon the XOR gate will toggle the output of the register.

The following is a generalized equation for a register (QN) in a binary-count sequence using the XOR PLD:

QN := QN :+: Q(N−1)*Q(N−2)*
. . . Q2*Q1*Q0

You can consider the term Q(N−1)*Q(N−2)* . . . Q2*Q1*Q0 as a Carry input to register QN.

When Q(N−1)*Q(N−2)* . . . Q2*Q1*Q0 = 0, the register QN is in a hold condition, and QN's output feeds back through the fuse array and the XOR gate and loads into itself. Only when

Q(N−1)*Q(N−2)* . . .
Q2*Q1*Q0 = 1

will the XOR function invert the polarity of QN and strobe the inverted state into the register in synchronicity with the rising edge of the next clock pulse.

Unlike MSI counters, which come with carry-in and carry-out pins, you must incorporate in your design provisions for cascading XOR PLDs.

The logic in the least significant counter can decode the penultimate count and feed the D input of a carry-output-enable register. When the counter increments to the final count, the carry-output-enable signal is then clocked into the carry-output-enable register. The propagation of the carry-output-enable signal to the next counter stage is therefore coincident with the generation of the output of the ultimate count from the

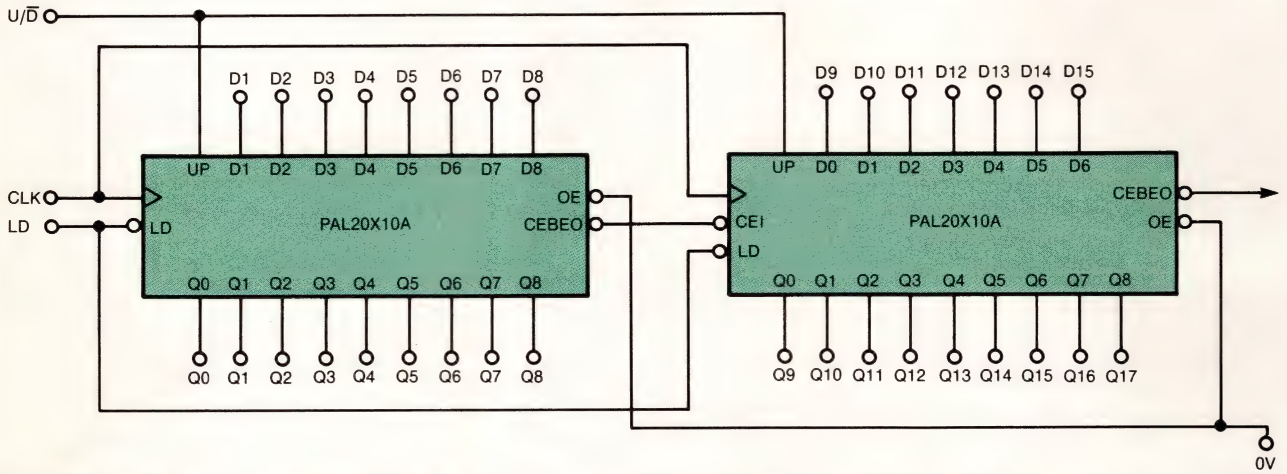
U/D̄
CLK
LD
D1 D2 D3 D4 D5 D6 D7 D8
UP D1 D2 D3 D4 D5 D6 D7 D8
OE
CEBEO
PAL20X10A
LD
Q0 Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8
D9 D10 D11 D12 D13 D14 D15
UP D0 D1 D2 D3 D4 D5 D6
CEBEO
OE
CEI
LD
PAL20X10A
Q0 Q1 Q2 Q3 Q4 Q5 Q6 Q7 Q8
Q9 Q10 Q11 Q12 Q13 Q14 Q15 Q16 Q17
0V

Fig 3a—Unlike the counter illustrated in Fig 2a, *this counter uses a look-ahead-carry-out technique. Provision of this signal renders the counter cascadable.*

Fig 3b

```
CEBEO  := UP*/Q0*Q1*Q2*Q3*Q4*Q5*Q6*Q7*Q8*/LD        ;
       + /UP*Q0*/Q1*/Q2*/Q3*/Q4*/Q5*/Q6*/Q7*/Q8*/LD ;
       :+: /UP*/D1*/D2*/D3*/D4*/D5*/D6*/D7*/D8*LD   ;
                                                    ;
                                                    ;
/Q0    := Q0*/LD                                    ;
       +  LD                                        ;
                                                    ;
/Q1    :=  /Q1*/LD                                  ;
       +   /D1*LD                                   ;
       :+: Q0*/LD*UP                                ;
       +   /Q0*/LD*/UP                              ;
                                                    ;
/Q2    :=  /Q2*/LD                                  ;
       +   /D2*LD                                   ;
       :+: Q0*Q1*/LD*UP                             ;
       +   /Q0*/Q1*/LD*/UP                          ;
                                                    ;
/Q3    :=  /Q3*/LD                                  ;
       +   /D3*LD                                   ;
       :+: Q0*Q1*Q2*/LD*UP                          ;
       +   /Q0*/Q1*/Q2*/LD*/UP                      ;
                                                    ;
/Q4    :=  /Q4*/LD                                  ;
       +   /D4*LD                                   ;
       :+: Q0*Q1*Q2*Q3*/LD*UP                       ;
       +   /Q0*/Q1*/Q2*/Q3*/LD*/UP                  ;
                                                    ;
/Q5    :=  /Q5*/LD                                  ;
       +   /D5*LD                                   ;
       :+: Q0*Q1*Q2*Q3*Q4*/LD*UP                    ;
       +   /Q0*/Q1*/Q2*/Q3*/Q4*/LD*/UP              ;
                                                    ;
/Q6    :=  /Q6*/LD                                  ;
       +   /D6*LD                                   ;
       :+: Q0*Q1*Q2*Q3*Q4*Q5*/LD*UP                 ;
       +   /Q0*/Q1*/Q2*/Q3*/Q4*/Q5*/LD*/UP          ;
                                                    ;
/Q7    :=  /Q7*/LD                                  ;
       +   /D7*LD                                   ;
       :+: Q0*Q1*Q2*Q3*Q4*Q5*Q6*/LD*UP              ;
       +   /Q0*/Q1*/Q2*/Q3*/Q4*/Q5*/Q6*/LD*/UP      ;
                                                    ;
/Q8    :=  /Q8*/LD                                  ;
       +   /D8*LD                                   ;
       :+: Q0*Q1*Q2*Q3*Q4*Q5*Q6*Q7*/LD*UP           ;
       +   /Q0*/Q1*/Q2*/Q3*/Q4*/Q5*/Q6*/Q7*/LD*/UP  ;
                                                    ;
```

Fig 3c

```
CEBEO    := UP*Q0*Q1*Q2*Q3*Q4*Q5*Q6*Q7*Q8*/LD             ;UP COUNT ENABLE
         + /UP*/Q0*/Q1*/Q2*/Q3*/Q4*/Q5*/Q6*/Q7*/Q8*/LD    ;DOWN COUNT ENAB
         :+: /UP*/D0*/D1*/D2*/D3*/D4*/D5*/D6*LD           ;ALL LOW ENABLE
                                                          ;
                                                          ;
/Q0      := Q0*/LD*CEI + /Q0*/LD*/CEI                     ;TOGGLE Q0
         :+:  LD*/D0                                      ;LOAD D0
                                                          ;
/Q1      :=  /Q1*/LD                                      ;HOLD Q1
         +   /D1*LD                                       ;LOAD D1
         :+: Q0*/LD*UP*CEI                                ;UP COUNT
         +   /Q0*/LD*/UP*CEI                              ;DOWN COUNT
                                                          ;
/Q2      :=  /Q2*/LD                                      ;HOLD Q2
         +   /D2*LD                                       ;LOAD D2
         :+: Q0*Q1*/LD*UP*CEI                             ;UP COUNT
         +   /Q0*/Q1*/LD*/UP*CEI                          ;DOWN COUNT
                                                          ;
/Q3      :=  /Q3*/LD                                      ;HOLD Q3
         +   /D3*LD                                       ;LOAD D3
         :+: Q0*Q1*Q2*/LD*UP*CEI                          ;UP COUNT
         +   /Q0*/Q1*/Q2*/LD*/UP*CEI                      ;DOWN COUNT
                                                          ;
/Q4      :=  /Q4*/LD                                      ;HOLD Q4
         +   /D4*LD                                       ;LOAD D4
         :+: Q0*Q1*Q2*Q3*/LD*UP*CEI                       ;UP COUNT
         +   /Q0*/Q1*/Q2*/Q3*/LD*/UP*CEI                  ;DOWN COUNT
                                                          ;
/Q5      :=  /Q5*/LD                                      ;HOLD Q5
         +   /D5*LD                                       ;LOAD D5
         :+: Q0*Q1*Q2*Q3*Q4*/LD*UP*CEI                    ;UP COUNT
         +   /Q0*/Q1*/Q2*/Q3*/Q4*/LD*/UP*CEI              ;DOWN COUNT
                                                          ;
/Q6      :=  /Q6*/LD                                      ;HOLD Q6
         +   /D6*LD                                       ;LOAD D6
         :+: Q0*Q1*Q2*Q3*Q4*Q5*/LD*UP*CEI                 ;UP COUNT
         +   /Q0*/Q1*/Q2*/Q3*/Q4*/Q5*/LD*/UP*CEI          ;DOWN COUNT
                                                          ;
/Q7      :=  /Q7*/LD                                      ;HOLD Q7
         +   LD                                           ;LOAD LOGIC LOW
         :+: Q0*Q1*Q2*Q3*Q4*Q5*Q6*/LD*UP*CEI              ;UP COUNT
         +   /Q0*/Q1*/Q2*/Q3*/Q4*/Q5*/Q6*/LD*/UP*CEI      ;DOWN COUNT
                                                          ;
/Q8      :=  /Q8*/LD                                      ;HOLD Q8
         +   LD                                           ;LOAD LOGIC LOW
         :+: Q0*Q1*Q2*Q3*Q4*Q5*Q6*Q7*/LD*UP*CEI           ;UP COUNT
         +   /Q0*/Q1*/Q2*/Q3*/Q4*/Q5*/Q6*/Q7*/LD*/UP*CEI  ;DOWN COUNT
                                                          ;
```

Palasm notation conventions

For consistency with the design specifications, the text of this article uses the Palasm notational conventions for Boolean operators instead of the classical symbols. Palasm is MMI's PAL assembler, which converts Boolean-logic equations into fuse maps for PLDs. *(Ed Note: Readers familiar with other PLD compilers may be more used to the C-language conventions used in Cupl and Abel. One compiler, logIC from Kontron, allows you, thankfully, to choose your own favorite symbol set.)*

- / represents a logical inversion.
- * represents a logical AND.
- + represents a logical OR.
- = represents a logical equality.
- :+: represents an exclusive-OR (XOR).
- := represents the state-machine operation "Becomes equal after the rising edge of a clock pulse."

registers in the least significant counter. By anticipating the ultimate count in this fashion, this scheme avoids the propagation delay involved in decoding the final count.

The counter designs specified by the sets of logic equations presented in **Figs 3b** and **3c** use this look-ahead-carry-out technique. The designs are cascadable, 9-bit up/down counters; **Fig 3c's** specification generates both Carry and Borrow signals on a look-ahead basis. You can use these specifications to create an 18-bit counter by routing the Carry/Borrow output (CEBEO) of the first up/down counter to the count-enable input (CEI) of the second up/down counter (**Fig 3a**). These counters are capable of clocking at rates as high as 22.2 MHz.

To cascade more than two counters for high-speed counting, your design would require a composite carry-enable output to the more significant counters in the chain. You would need to generate a look-ahead-carry output from only the least significant counter; higher-order counters in the chain would require a count-enable output generated from the ultimate, or final, count rather than the penultimate count. **Fig 4a** shows a technique for cascading more than two counters in a synchronous-count chain. Depending upon the availability of input pins, you could incorporate the required gates into the PLD itself, as **Fig 4b** shows.

XOR PLDs have many applications outside of binary counting. The example of a video shift register shows how video applications can benefit from the programmable-polarity feature of the XOR gate.

Fig 5a shows a typical video system using the PAL20X8A. **Fig 5b** gives the PLD design specification. An XOR PLD, when functioning as a video-shift register, loads row data, in parallel, from a character ROM or RAM. A control input to the XOR PLD (reverse

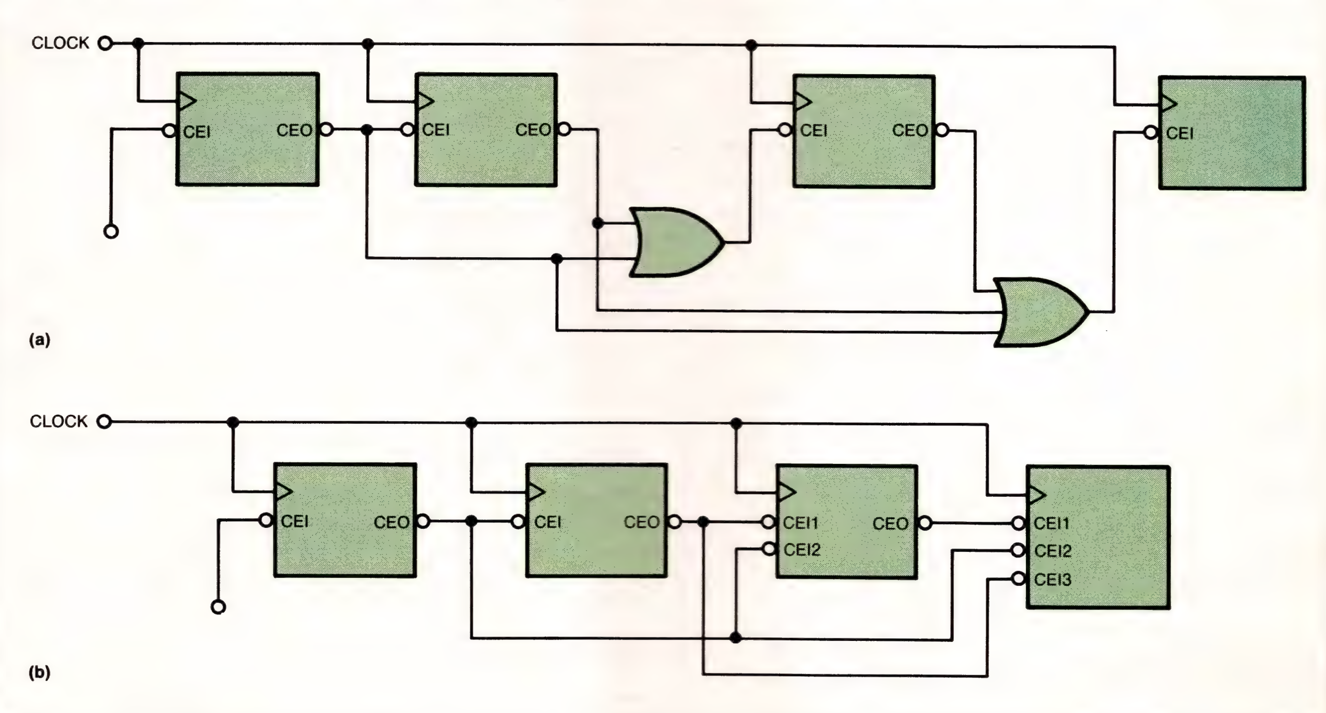

Fig 4—You can cascade two or more XOR-PLD counters *in a synchronous-count chain with either external* ***(a)*** *or internal* ***(b)*** *logic.*

The XOR PLD series has many applications outside of binary counting.

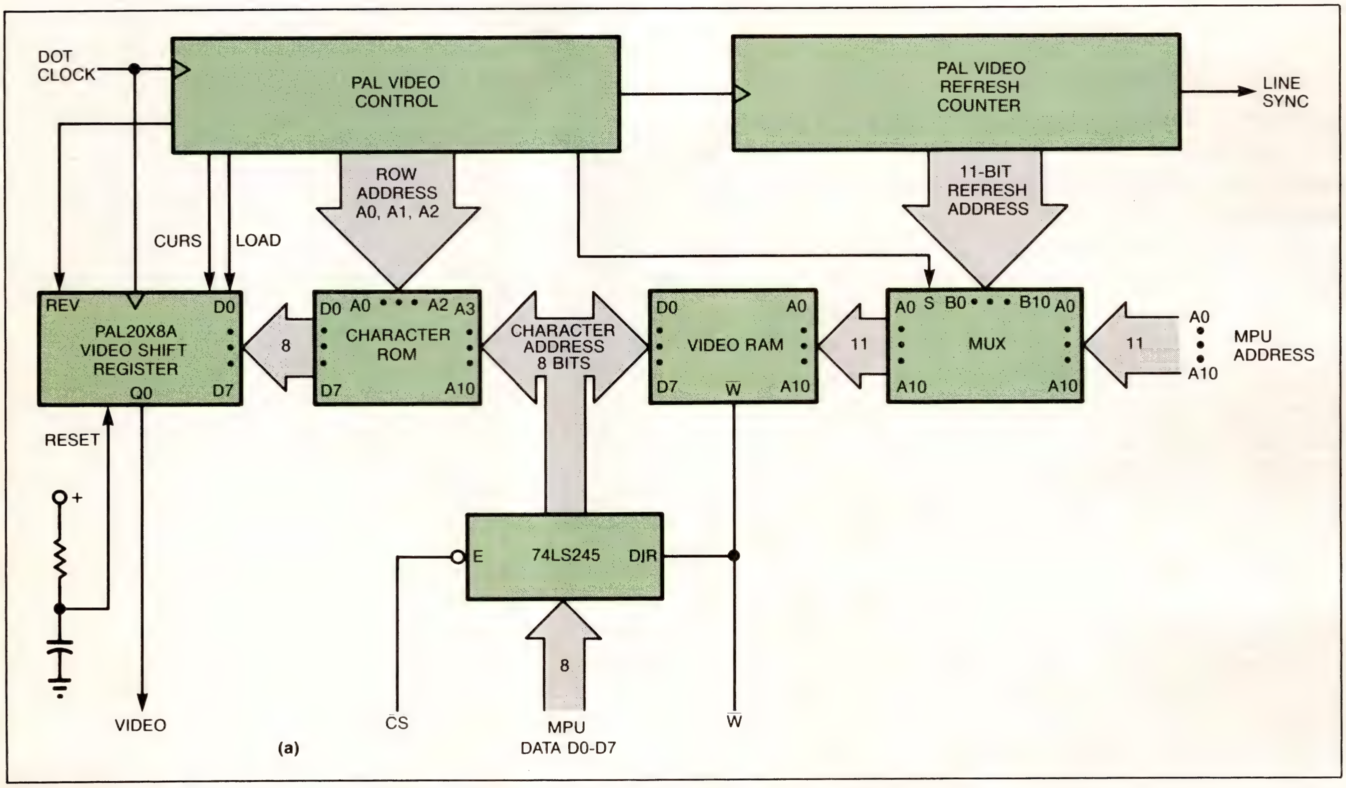

Fig 5a—XOR PLDs suit other applications besides counters. *The device's programmable output polarity is a vital part of this design, which uses an XOR PLD as a video shift register that incorporates a cursor control.*

Fig 5b

```
/Q0 := /D0*LD*/REV*/CURS*/RST        ;LOAD D0
       + D0*LD*REV*/CURS*/RST        ;LOAD INVERSE OF D0
       :+: /Q1*/LD*/CURS*/RST        ;SHIFT FROM Q1
       + RST                         ;RESET Q0 LOW
                                     ;
                                     ;CURSOR LOW CLEARS /Q0
/Q1 := /D1*LD*/REV*/CURS*/RST        ;LOAD D1
       + D1*LD*REV*/CURS*/RST        ;LOAD INVERSE OF D1
       :+: /Q2*/LD*/CURS*/RST        ;SHIFT FROM Q2
       + RST                         ;CURSOR LOW CLEARS /Q1
                                     ;RESET CLEARS Q1
/Q2 := /D2*LD*/REV*/CURS*/RST        ;LOAD D2
       + D2*LD*REV*/CURS*/RST        ;LOAD INVERSE OF D2
       :+: /Q3*/LD*/CURS*/RST        ;SHIFT FROM Q3
       + RST                         ;CURSOR LOW CLEARS /Q2
                                     ;RESET CLEARS Q2
/Q3 := /D3*LD*/REV*/CURS*/RST        ;LOAD D3
       + D3*LD*REV*/CURS*/RST        ;LOAD INVERSE OF D3
       :+: /Q4*/LD*/CURS*/RST        ;SHIFT FROM Q4
       + RST                         ;RESET CLEARS Q3
                                     ;CURSOR LOW CLEARS /Q3
/Q4 := /D4*LD*/REV*/CURS*/RST        ;LOAD D4
       + D4*LD*REV*/CURS*/RST        ;LOAD INVERSE OF D4
       :+: /Q5*/LD*/CURS*/RST        ;SHIFT FROM Q5
       + RST                         ;CURSOR LOW CLEARS /Q4
                                     ;RESET CLEARS Q4
/Q5 := /D5*LD*/REV*/CURS*/RST        ;LOAD D5
       + D5*LD*REV*/CURS*/RST        ;LOAD INVERSE OF D5
       :+: /Q6*/LD*/CURS*/RST        ;SHIFT FROM Q6
       + RST                         ;CURSOR LOW CLEARS /Q5
                                     ;RESET CLEARS Q5
/Q6 := /D6*LD*/REV*/CURS*/RST        ;LOAD D6
       + D6*LD*REV*/CURS*/RST        ;LOAD INVERSE OF D6
       :+: /Q7*/LD*/CURS*/RST        ;SHIFT FROM Q7
       + RST                         ;CURSOR LOW CLEARS /Q6
                                     ;RESET CLEARS Q6
/Q7 := /D7*LD*/REV*/CURS*/RST        ;LOAD D7
       + D7*LD*REV*/CURS*/RST        ;LOAD INVERSE OF D7
       :+: /LD*/CURS*/RST            ;SHIFT HIGH INTO /Q7
       + RST                         ;RESET CLEARS Q7
                                     ;
```

video, or REV) determines whether or not the data loaded into the register is to be inverted. Therefore, the XOR PLD can supply normal-video or reverse-video information.

This design also incorporates a cursor control, which, when active, sets all of the register's outputs high. The design also has a reset line to clear all the registers. When you release the load input, the clock input will serially clock the data out of register Q0 as a video-data stream. The clock input to the PLD determines the dot rate of the video information and must come from an external dot-rate generator.

The Palasm logic-equation files presented in this article omit comments, pin definitions, and device-simulator specifications because of space limitations. If you want the entire Palasm file, you may call the author at (408) 970-9700. **EDN**

Author's biography

Chris Jay is applications manager at Monolithic Memories Inc (Santa Clara, CA), where he has worked for four years. He previously worked for Fairchild and Texas Instruments in the UK. Chris obtained a BSc in electronics from Essex University in England, and he is a member of the Institute of Electrical Engineers, London. His hobbies include photography, electronics, and traveling.

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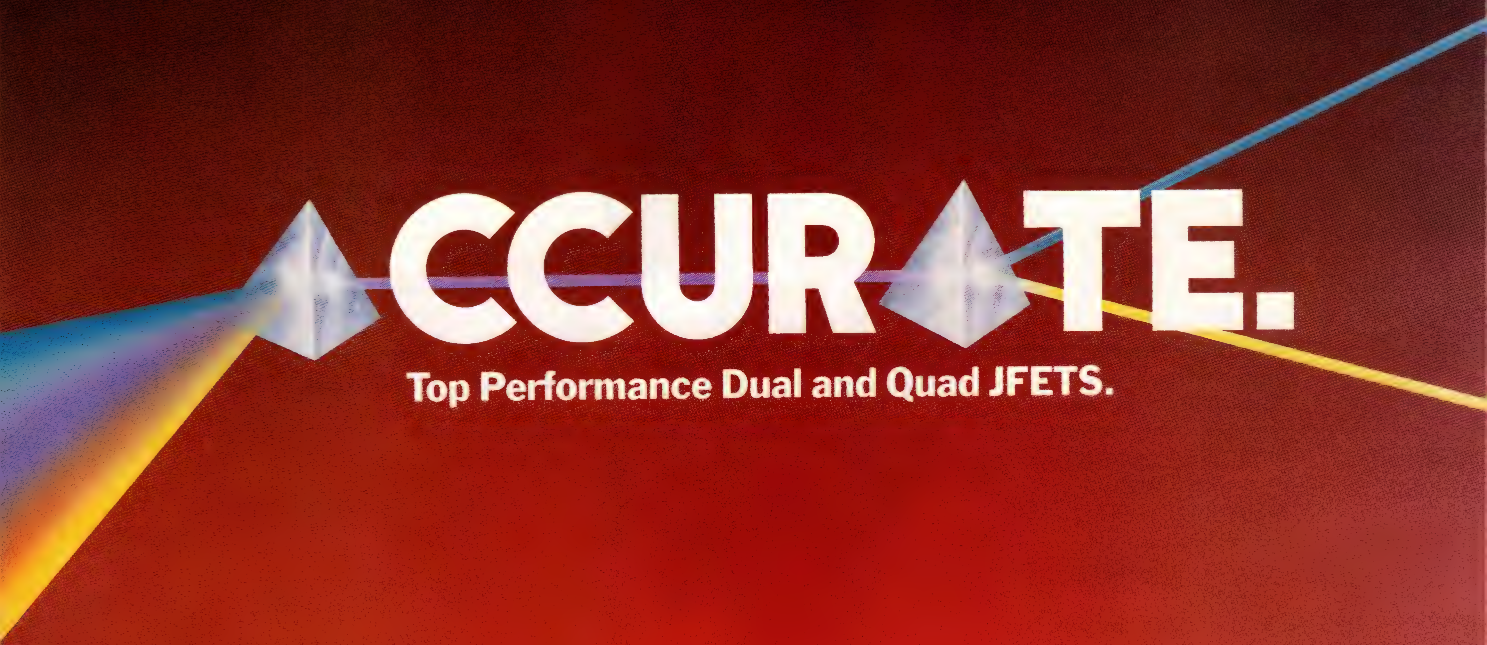

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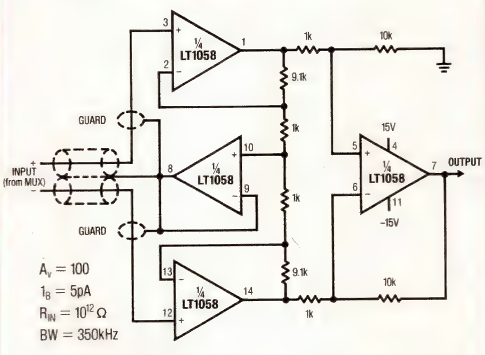

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DESIGN IDEAS

EDITED BY TARLTON FLEMING

Increase sequence generator's clock rate

Richard Shaner and Steve Lubs
Dept of Defense, Washington, DC

The 10K ECL circuit of **Fig 1a** is a pseudorandom-sequence generator useful in simulating data for testing communications lines. The output is a serial sequence of seven to 127 bit values, depending on the switch settings of S_1 to S_9. By using a parity checker (IC_1) in place of the otherwise-required multilevel XOR network in **Fig 1b**, the circuit achieves a 20% increase in clock rate, to 54 MHz max. Other advantages of this circuit include a lower parts count and fewer interconnections. Gates IC_{7B}, IC_{8A}, and IC_{8B} form a self-starting circuit that prevents latch-up when the generator produces a sequence of all zeros. **EDN**

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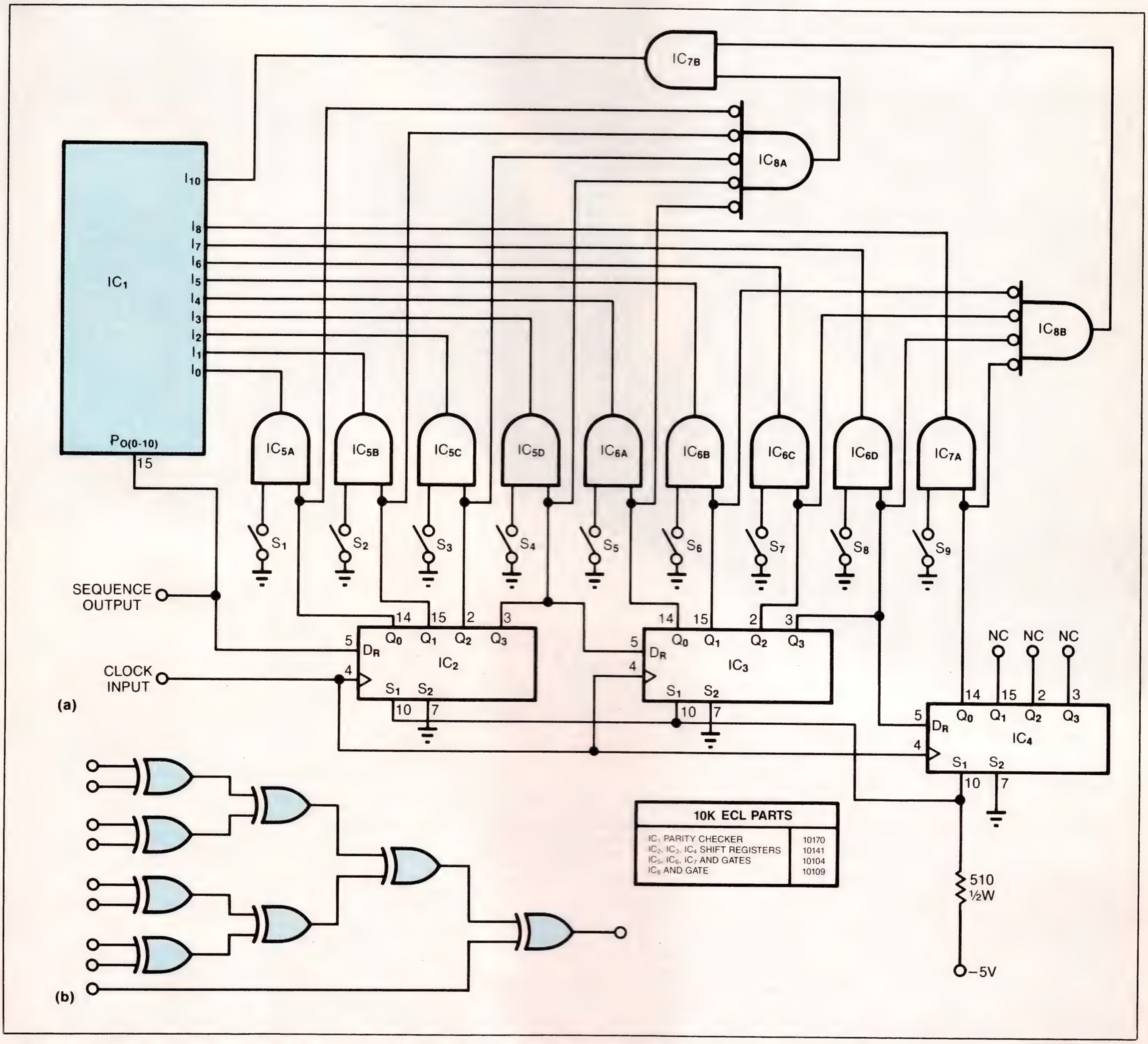

10K ECL PARTS	
IC_1 PARITY CHECKER	10170
IC_2, IC_3, IC_4 SHIFT REGISTERS	10141
IC_5, IC_6, IC_7 AND GATES	10104
IC_8 AND GATE	10109

Fig 1—This pseudorandom-sequence generator (a) *produces digital sequences that range in length from seven to 127 bits, depending on the state of the switches. The circuit uses a parity checker (IC_1) instead of an XOR network* ***(b)*** *and allows clock rates as high as 54 MHz.*

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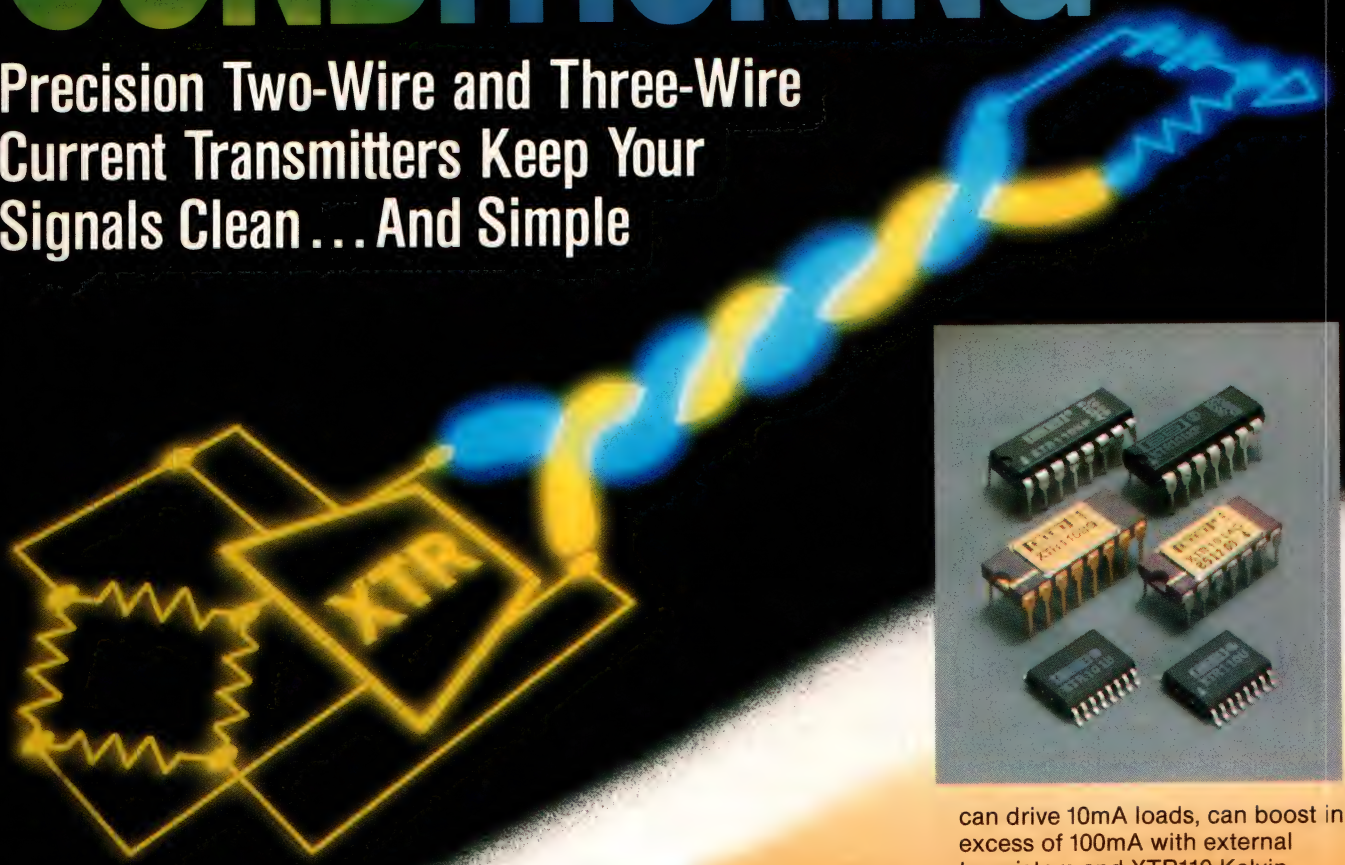

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Kerry Lacanette
National Semiconductor Corp, Santa Clara, CA

The AGC (automatic gain control) circuit in **Fig 1** maintains a constant output-voltage level of 10V p-p for repetitive waveforms. The circuit senses the input amplitude and adjusts the output gain once every cycle, returning the output amplitude to its proper level within two cycles. (Conventional AGC circuits respond much more slowly to avoid modulating the gain within one cycle of a low-frequency input signal.)

The digital approach in **Fig 1** has other advantages as well. Using an A/D converter for input-amplitude sensing eliminates the conventional gain-control element (a FET, a saturated bipolar transistor, a light-dependent resistor, or a voltage- or current-controlled amplifier), which can introduce distortion, noise, and gain error. Using a CMOS D/A converter provides accurate gain control and introduces less than 0.1% distortion. Further, the open-loop circuit isn't subject to instability.

AGC action improves with input amplitude, which

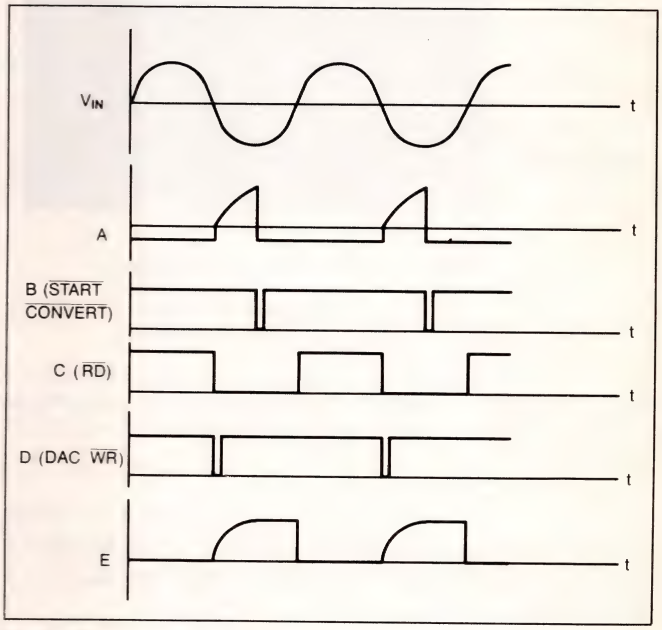


***Fig 2—These analog and digital waveforms** depict the operation of Fig 1's AGC circuit.*

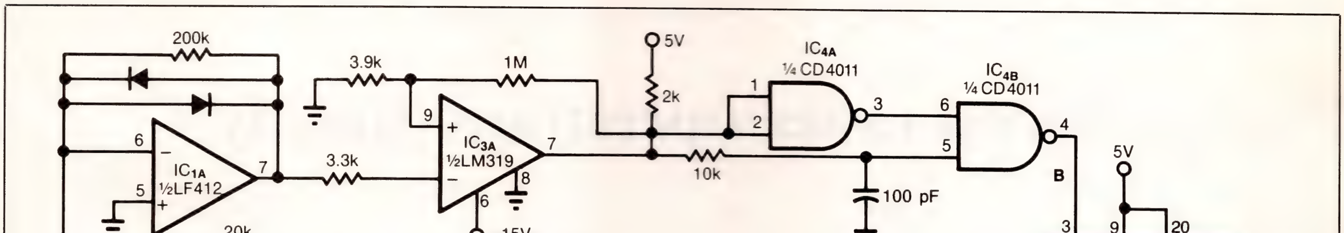
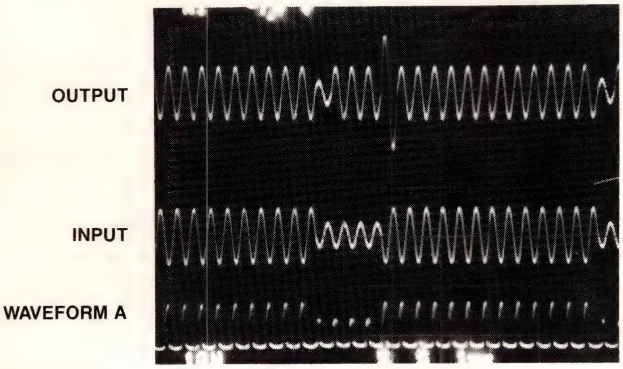


***Fig 1—This automatic gain-control circuit** uses an open-loop digital technique to maintain the output amplitude at 10V p-p.*



TRACE	HORIZONTAL	VERTICAL
OUTPUT	1 mSEC/DIV	10V/DIV
INPUT	1 mSEC/DIV	5V/DIV
WAVEFORM A	1 mSEC/DIV	5V/DIV

Fig 3—The top trace shows Fig 1's AGC action. *Following a change in input amplitude, the output amplitude returns to the proper level within two cycles.*

should be between 1 and 10V. AGC control is better than 0.1 dB for amplitudes above 5V p-p and about 0.4 dB for a 1V p-p input. The input frequency range is 1 Hz to 5 kHz.

Op amps IC_{2A} and IC_{2B} constitute a peak-detector circuit in which the hold capacitor (C_1) captures the peak amplitude during a negative half cycle of the input signal. (Transistor Q_1 discharges C_1 during the input's positive half cycle.) Waveform A drops to 0.7V as the input passes its negative peak value, as you can see in **Fig 2.**

Comparator IC_{3A} senses the zero crossing that follows the input signal's negative peak, causing the NAND gates IC_{4A} and IC_{4B} to generate a negative $\overline{WR}$ pulse that triggers a conversion by IC_5, the 8-bit A/D converter. The diode-clamped amplifier IC_{1A} protects the comparator from overdrive (input diodes protect the other comparator, IC_{3B}).

IC_{3B}'s output drives the A/D converter's $\overline{RD}$ signal low when the input signal is negative, placing the converter's output on the data bus. Next, NAND gates IC_{4C} and IC_{4D} generate a negative $\overline{WR_1}$ pulse that latches the data into the D/A converter IC_6, thereby adjusting the gain of the output amplifier IC_{1B} to oppose any change in the input signal's amplitude. **Fig 3** illustrates this action. **EDN**

To Vote For This Design, Circle No 746

PLD performs raster operations directly

Kapil Shankar
Advanced Micro Devices, Sunnyvale, CA

The limited number of product terms available on most programmable logic devices (PLDs) restricts their direct use in performing raster operations such as picture mixing, animation, half-tone generation, and reverse video. You can use a PLD, though, if you first encode the various combinations of logic operations that each pixel has to perform.

Raster operations require data manipulation, or bit-boundary block transfers (Bit Blit), which involve high-speed data transfers from one area of a frame buffer (graphics memory) to another. In **Fig 1,** you can see the block diagram and bit-plane organization of a graphics system with 4-bit resolution. The PLD, IC_1, executes the desired raster operation by performing logical operations (AND, OR, XOR, and NOT) on corresponding pixels from the source areas A and B. The system then stores this result in a destination area of the frame buffer.

Most standard PLDs provide no more than eight

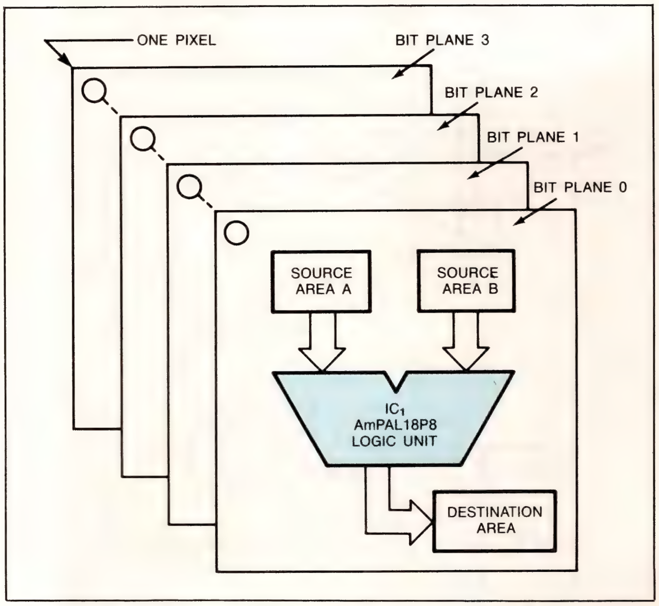


Fig 1—The logic unit in a graphics system *(IC_1 in this case) operates on one or more data bits at a time. The PLD takes the bits from corresponding locations in each source area and writes the result to a destination area.*

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	end, min.	200	400	600	800	1200	1600	1600	1600	1800	2000	2100	2200
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*Prefix P for pins, B for BNC, N for Type N, S for SMA   example: PLP-10.7

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product terms on each output, yet more than 25 terms per destination bit are necessary to represent all the possible combinations of logic operations that you can apply to the two source bits (one each from areas A and B). Only 16 raster operations are possible on the two source bits, however. A technique called bit-pair encoding allows the PLD to perform all 16 raster operations with only four product terms.

TABLE 1—TRUTH TABLE FOR RASTER OPERATIONS

S_0 $(A*B)$	S_1 $(\overline{A}*B)$	S_2 $(A*\overline{B})$	S_3 $(\overline{A}*\overline{B})$	DESTINATION (D)
0	0	0	0	0
0	0	0	1	$A*B$
0	0	1	0	$A*\overline{B}$
0	0	1	1	A
0	1	0	0	$\overline{A}*B$
0	1	0	1	B
0	1	1	0	A XOR B
0	1	1	1	$A+B$
1	0	0	0	$\overline{A}*\overline{B}$
1	0	0	1	A XNOR B
1	0	1	0	$\overline{B}$
1	0	1	1	$A+B$
1	1	0	0	$\overline{A}$
1	1	0	1	$\overline{A}+B$
1	1	1	0	$\overline{A}+\overline{B}$
1	1	1	1	1

*: AND   + : OR

First it's necessary to encode A and B as $(A*B)$, $(A*\overline{B})$, $(\overline{A}*B)$, and $(\overline{A}*\overline{B})$. Then, to generate the destination bit, D, you combine these functions with the raster-op selection bits S_0-S_3, which originate in the graphics processor:

$$D = (A*B*S_0) + (\overline{A}*B*S_1) + (A*\overline{B}*S_2) + (\overline{A}*\overline{B}*S_3).$$

These encoded functions then combine in accordance with the weight of the selection bits, producing the 16 possible raster operations as shown in **Table 1.** **EDN**

To Vote For This Design, Circle No 748

Current source has programmable TC

Larry D Taylor and Frank M Caimi
Harbor Branch Oceanographic Institution Inc, Fort Pierce, FL

The current source in **Fig 1** has an output (labeled I_K) with a programmable temperature coefficient. You can set I_K's TC to any desired value in the range of −1.1 to +0.3%/°C by choosing appropriate values for resistors R_S and R_D. You can then either use I_K directly to compensate for unwanted temperature effects in a circuit, or you can connect a potentiometer (shown with broken lines) to produce a variable voltage source whose TC is independent of the supply voltage.

The adjustable current source IC_1 has an output TC of 0.33%/°C, and the Schottky diode D_1 (operating at a forward voltage of 77 mV) has a TC of −1.85 mV/°C. By varying the ratio of R_S and R_D, you can determine what proportion of each resistor's TC affects I_K.

Fig 2 lets you choose the resistor values that will produce an I_K temperature coefficient in the allowed range. For example, if you want to produce a TC of 0.1%/°C, R_D should equal 10.5 kΩ and R_S should equal 801Ω. Note that the resistor values are based on a nominal load current of 100 μA at 25°C. IC_1 can provide as much as 10 mA, but limiting the current to 100 μA minimizes errors due to self-heating. (The **Fig 1** circuit's TC displays 0.4% linearity over the temperature range of 5 to 40°C.)

You should remember that the resistors' TC will affect the TC of I_K. Resistors with a 100-ppm/ °C

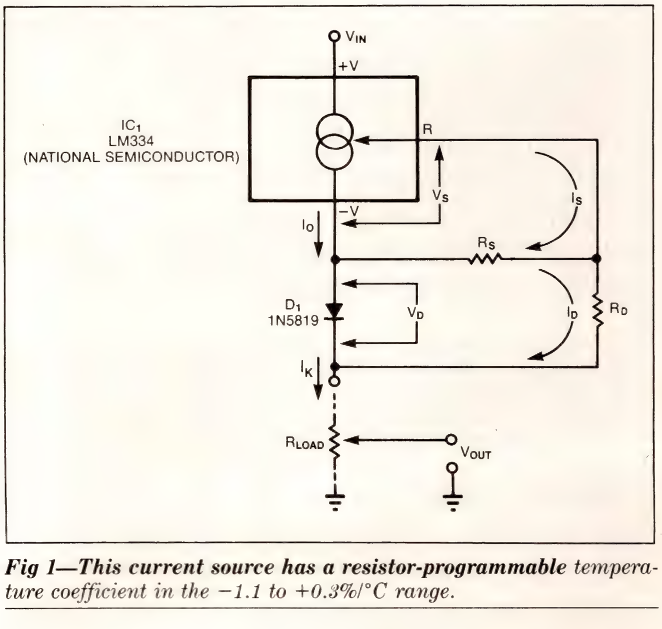

Fig 1—This current source has a resistor-programmable temperature coefficient in the −1.1 to +0.3%/°C range.

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The Z8536 CIO incorporates I/O and counter/timers in one chip.

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- Three 16-bit counter/timers
- IEEE-488 compatible
- 4 handshake modes

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The Z8038 FIO is a skilled arbitrator with high-speed transfer logic.

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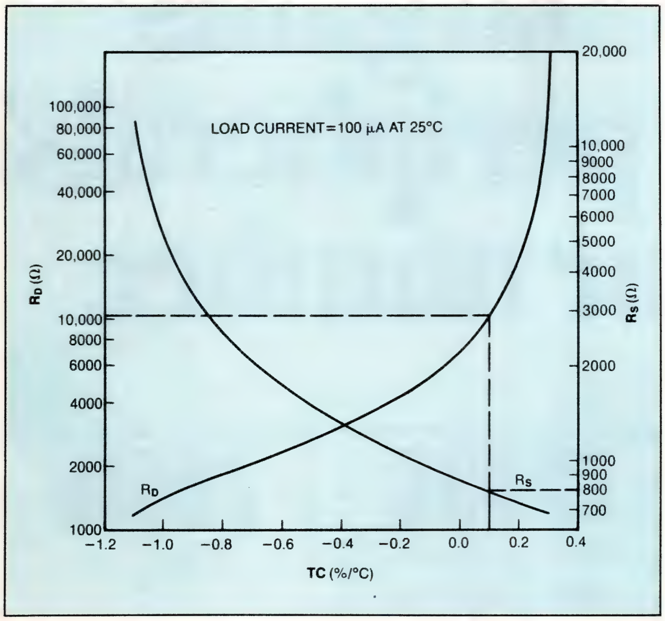

***Fig 2—Using these curves, you can determine the** resistor values of* ***Fig 1** necessary to achieve a desired temperature coefficient.*

TC, for instance, will produce an approximate ±100-ppm/°C error in I_K's temperature coefficient. You should also note that your application must produce the minimum turn-on voltage (1V) across IC_1.

To derive an expression for the output TC ($\Delta I_K/\Delta T$), you assign the loop currents I_S and I_D in **Fig 1** and write the loop equations as follows:

$$V_S=(I_S-I_D)R_S$$

and

$$V_D=(I_D-I_S)R_S+I_DR_D.$$

Solve for I_S. Because $I_K=I_O+I_S$ and $I_O=I_S/18$ (included in the LM334's data sheet), $I_K=1.055I_S$. Thus, the desired temperature coefficient, expressed as a percent, is

$$\frac{\Delta I_K}{I_K\Delta T}=(100)\left[\frac{\frac{\Delta V_S}{\Delta T}\left(\frac{1}{R_D}+\frac{1}{R_S}\right)+\frac{\Delta V_D}{\Delta T}\left(\frac{1}{R_D}\right)}{V_S\left(\frac{1}{R_D}+\frac{1}{R_S}\right)+\frac{V_D}{R_D}}\right],$$

where $\Delta V_S/\Delta T=0.215$ mV/°C and $V_S=64$ mV (also included in the data sheet). You can modify this equation to accommodate other diode types and circuit configurations. The Schottky diode, however, is useful because it has a large negative temperature coefficient and because the TC variation is negligible from lot to lot. **EDN**

To Vote For This Design, Circle No 747

Multivibrator achieves near-50% duty cycle

Edward W Rummel
Robin Baker Associates Inc, Short Hills, NJ

The 3-component astable multivibrator of **Fig 1** provides an output with a near-50% duty cycle. Using this circuit, you don't need the additional flip-flop usually required to obtain such a duty cycle. What's more, the CMOS timer shown costs a penny less than often-used equivalent bipolars (100-piece price).

Three factors contribute to the output symmetry. The capacitor charges and discharges through the same external resistor. An internal resistive divider sets accurate switching thresholds within the chip (the bipolar types use dividers as well). And most important, IC_1's CMOS output stage switches fully between ground and V_{CC}, avoiding the errors due to asymmetry that are often found in a TTL timer's output. The IC's internal switching-threshold tolerances can cause a deviation of several percent from the desired 50% duty cycle. To meet a tighter specification, you might have to select from a group of ICs. **EDN**

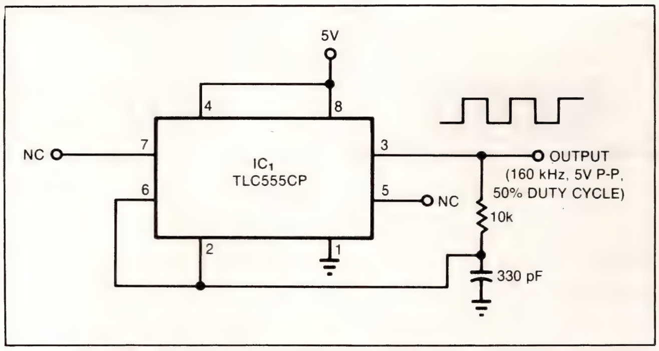

***Fig 1—Based on a CMOS version of a 555 timer,** this astable multivibrator's output symmetry depends on the tolerance of the internal switching thresholds.*

To Vote For This Design, Circle No 749

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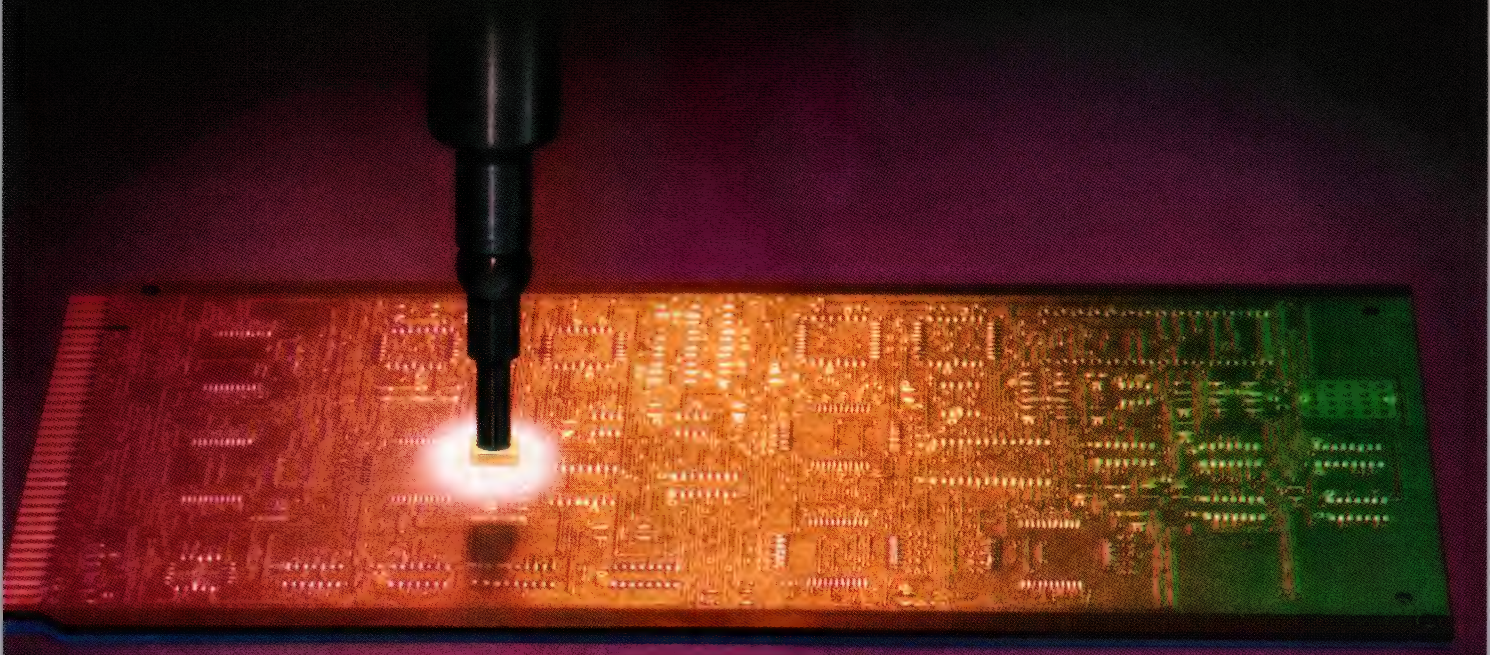

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The winning Design Idea for the March 4, 1987, issue is entitled "Pulse-delay circuit has dual-edge trigger," submitted by S Murugesan of ISRO Satellite Centre (Bangalore, India).

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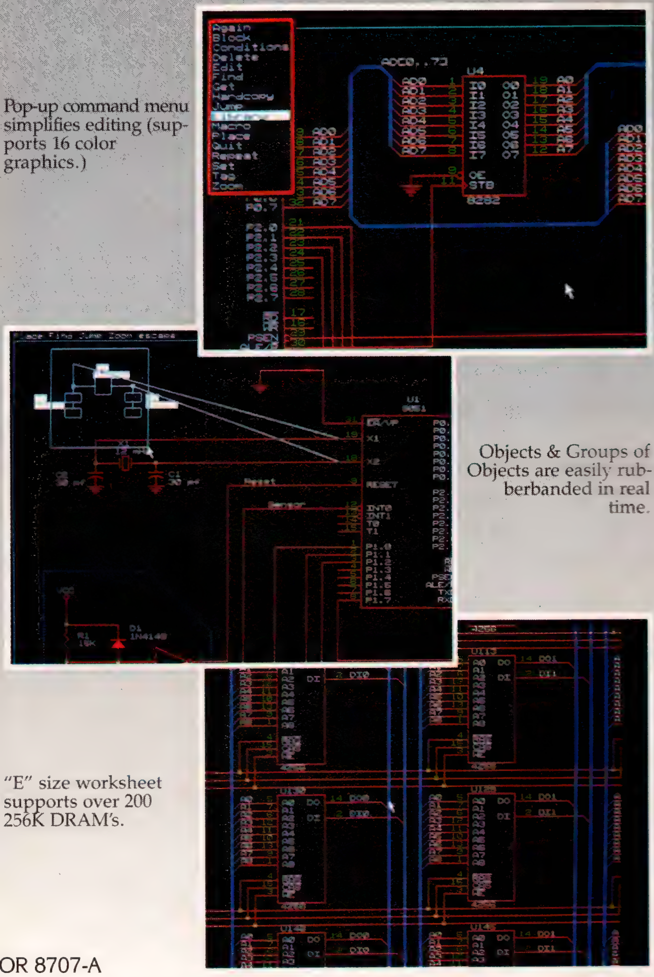

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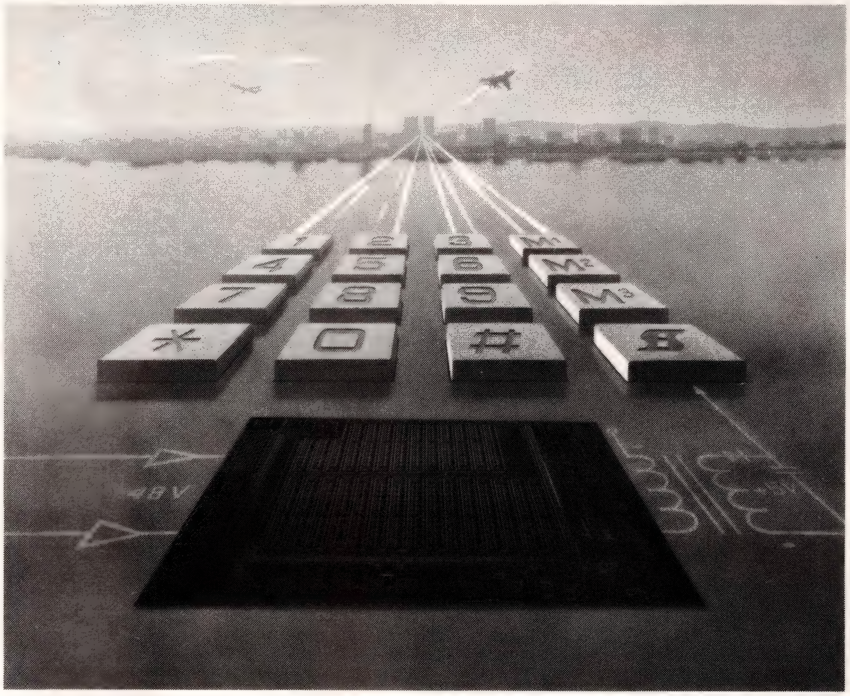
The Si9100 is a high-voltage switching regulator IC that uses both DMOS and CMOS technology. It supports the design of 80%-efficient, 1W regulators that accept input voltages as high as 70V. The device contains high-voltage startup circuitry and a power-MOSFET output switch in addition to the standard pulse-width-modulator (PWM) control circuitry. The PWM circuitry uses current-mode control, which provides easy stabilization, internal pulse-by-pulse current limiting, and a feedforward connection for fast response to input-line variations. You use a single external resistor to set the internal oscillator for frequencies as high as 1 MHz. Shutdown and reset features provide remote on/off control, either latched or unlatched. Available for the commercial and industrial temperature ranges, the device comes in a 14-pin plastic or ceramic DIP. In plastic, $4.55; in ceramic, $12.50 (1000).

Siliconix Inc, 2201 Laurelwood Rd, Santa Clara, CA 95054. Phone (408) 988-8000.

Circle No 351



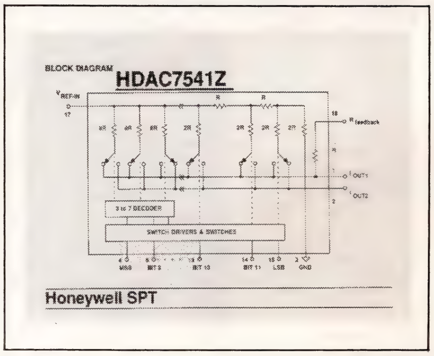
DUAL UARTs

- *Two independently programmable, full-duplex channels*
- *Screened per MIL-STD-883, Rev C*

The 2681/BQC and 68681/BQC NMOS dual UARTs meet the requirements of MIL-STD-883, Rev C. Both devices come in 40-pin DIPs. Each provides two independent, full-duplex asynchronous channels. In addition, the 68681's interrupt and DTACK handshaking circuitry simplifies the hardware interface to a 68000 μP. You can independently program each channel's operating mode and data format. You choose an operating speed from one of 18 fixed baud rates, from a 16× clock derived from the onboard counter/timer, or from an external 1× or 16× clock. Because you can program the receiver's and transmitter's speeds independently, these devices are well suited for 2-speed-channel applications. $44 (100).

Signetics Corp, Box 3409, Sunnyvale, CA 94088. Phone (408) 991-2000.

Circle No 352



D/A CONVERTER

- *End-point linearity is ±½ LSB*
- *Settling time to ±0.01% is 500 nsec*

The HDAC7541Z is a monolithic, 12-bit multiplying D/A converter with an industry-standard pinout. The manufacturer states that the converter offers the lowest gain error (0.75 LSB), lowest output glitch error (400 nV sec), and the lowest feedthrough error (0.5 mV p-p) in the industry. The device settles in 500 nsec. The output capacitance is less than 75 pF with all inputs low and less than 30 pF with all inputs high. The end-point linearity is ±½ LSB. The basic structure, fabricated using an epitaxial process, eliminates latchup and consequently the need for external Schottky clamp diodes. The parts are specified for the commercial,

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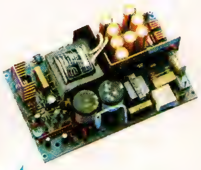
So if your product needs a power supply PDQ that meets VDE, UL, CSA, ETC., call ASAP. Sierra Power Systems (formerly Sierracin), 20500 Plummer Street, Chatsworth, California 91311. Call toll-free (800) 423-5569. In California, (818) 998-9873.



Sierra Power Systems
Division of Valor Electronics, Inc.

CIRCLE NO 177

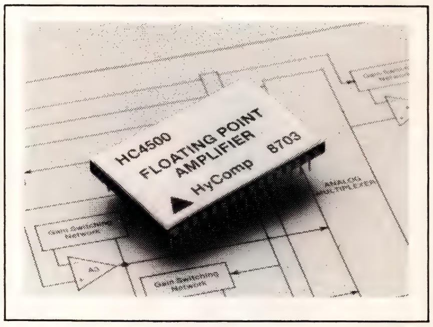
industrial, or military temperature range. They come in 18-pin plastic or ceramic DIPs, or as unpackaged chips. $7.40 (500).

Honeywell Inc, Signal Processing Technologies, 1150 E Cheyenne Mountain Blvd, Colorado Springs, CO 80906. Phone (303) 577-3511.

Circle No 353

HYBRID AMPLIFIER

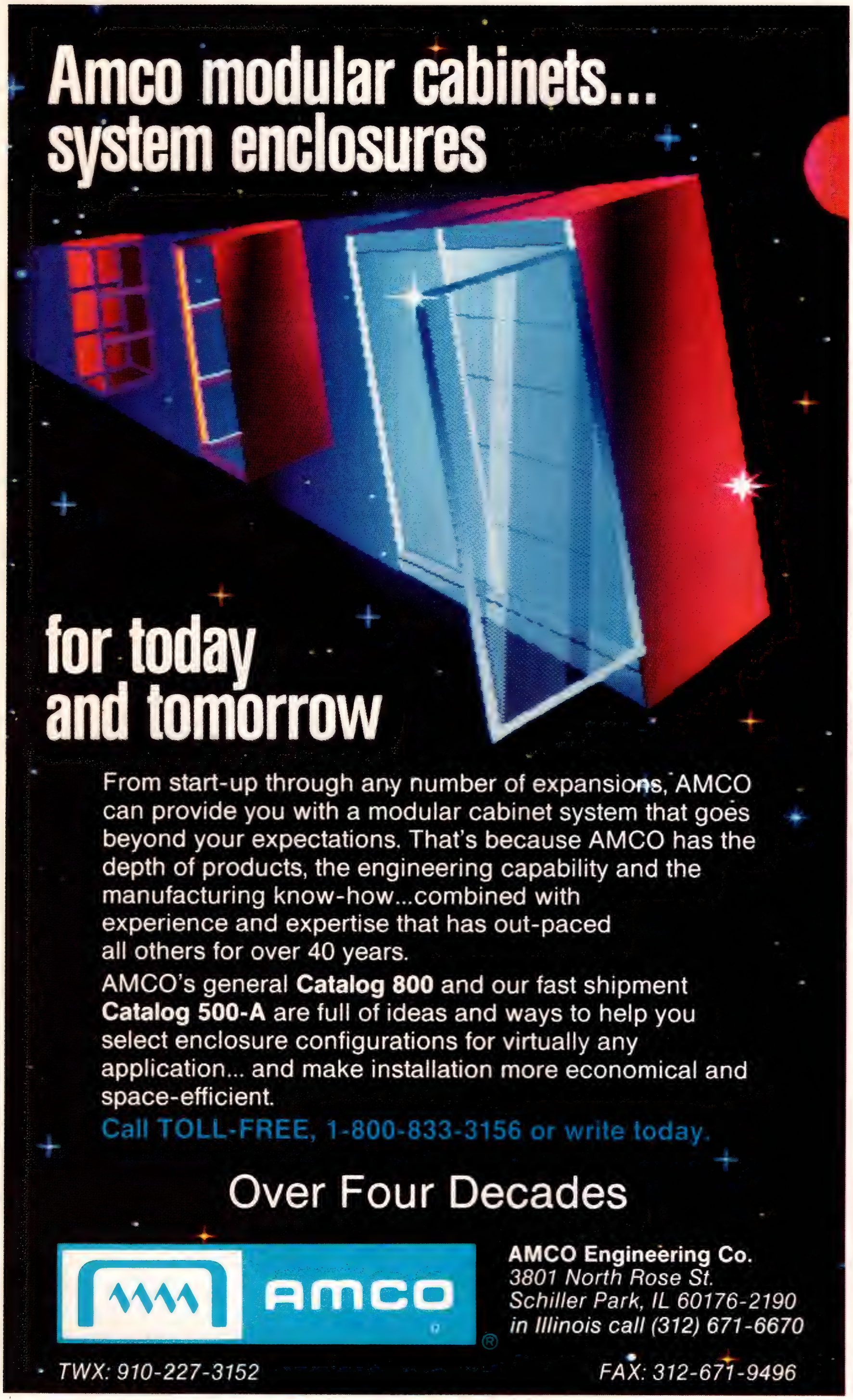
- *Gain ranges from 1 to 2048*
- *Settling time is independent of gain*



The HC4500 is a hybrid, floating-point amplifier in which one to five internal amplifiers (depending on the selected gain range) operate in a cascaded configuration. The device offers 12 power-of-2 gain ranges from 1 to 2048. Spreading the gain over several stages minimizes the dependence of settling time on the gain range: The 5V settling time to ±0.01% for a gain of 1 is 10 μsec max, and for a gain of 2048 it's 15 μsec typ. The maximum linearity error is ±0.01%, including the discontinuities between gain ranges. The small-signal bandwidth is 20 kHz; the typical input offset voltage is about 300 μV. Laser-trimmed NiCr thin-film resistors provide a typical gain drift of 12 ppm/°C and a typical offset drift of 10 μV/°C. The part is available in commercial and high-reliability versions. The package is a 32-pin DIP. $225.

HyComp Inc, 165 Cedar Hill St, Marlborough, MA 01752. Phone (617) 485-6300. TWX 710-347-0385.

Circle No 354



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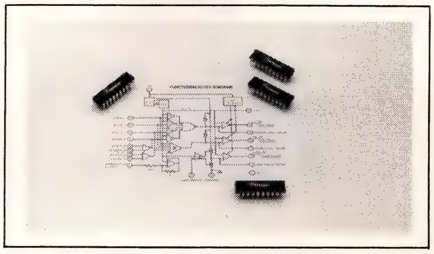


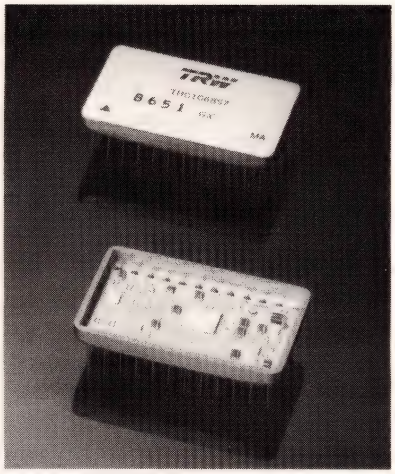
SUPPLY MONITOR

- *Monitors four power supplies*
- *Detects over- or undervoltages and line faults*

The ULN-8131A monitors four power supplies at a time and signals when any overvoltage or undervoltage condition exists. In a typical application, the chip might monitor a 5V supply, a ±15V supply, and a positive high-voltage peripheral supply. In addition, the chip monitors its own 10 to 35V supply voltage and signals when any power loss occurs. The device comes calibrated to within 1% of its trimmed 2.5V bandgap voltage reference, which is rated at 10 mA. $3.78 (100). Delivery, 12 weeks ARO.

Sprague Electric Co, 92 Hayden Ave, Lexington, MA 02173. Phone (617) 853-5000.

Circle No 355



A/D CONVERTER

- *20-MHz operation*
- *Has analog-input conditioning circuitry*

The THC1068 8-bit hybrid flash converter requires only a TTL clock and a bipolar analog input for operation. The device includes an input amplifier, a bandgap voltage reference, and 3-state outputs. You program the pins of the device, which comes in a 24-pin DIP, to accept positive, negative, or bipolar analog inputs. The converter operates over the military temperature range and meets the test and reliability requirements of MIL-STD-883B, Rev C. Hybrid Systems (Billerica, MA) will be a second source. Samples are available now; the full-military version will be available in June. $375 (100).

TRW, LSI Products Div, Box 2472, La Jolla, CA 92038. Phone (619) 457-1000.

Circle No 356

ISOLATION AMPS

- *3500V rms unity-gain isolation*
- *Feature 12-bit accuracy*

The ISO102 and -106 isolation amplifiers use a capacitive isolation barrier to achieve unity-gain isolation as high as 1500V rms (-102) and 3500V rms (-106). The devices employ thick-film, tungsten capacitors buried in ceramic. Both parts spec 12-bit accuracy, have ±10V input and output ranges, and operate over the industrial temperature range. They have a 70-kHz typ small-signal bandwidth and 130-dB typ isolation-mode rejection. The devices operate from ±10 to ±20V; you must provide an external, isolated power supply. The amplifiers come in 600-

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mil side-brazed ceramic DIPs that are compatible with automatic assembly equipment. A demonstration kit is available. ISO102, $16.50; ISO106, $22 (100).

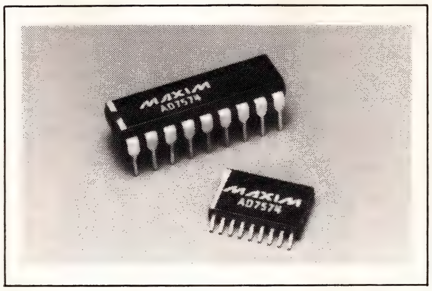
Burr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TWX 910-952-1111.

Circle No 357

A/D CONVERTER

- *Performs an 8-bit conversion in 15 μsec*
- *Comes in SO surface-mount package*

The AD7574 is a direct replacement for CMOS, μP-compatible, 8-bit A/D converters that have the same part number but are manufactured by others. Using the successive-approximation technique, the device converts in 15 μsec max. Features include latched, 3-state data outputs, an onboard clock, 5V operation, and a μP interface that allows the converter to appear either as a memory location or as an I/O port to a computer system. The part consumes 25 mW max. You can order the converter for the commercial, industrial, or military temperature ranges and in linearity grades of ±⅞ or ±¾ LSB. Parts come in an SO package or an 18-pin plastic or ceramic DIP. Commercial-grade SO versions from $8.25; other packages and grades, from $7.50 (100).



Maxim Integrated Products, 510 N Pastoria Ave, Sunnyvale, CA 94086. Phone (408) 737-7600.

Circle No 358

STATIC RAM

- *Has 16k×4-bit organization*
- *Access time of 30 nsec*

The MCM6288P30 is a CMOS static RAM organized as 16k×4 bits. Its access time is 30 nsec. The package is a 300-mil, 22-pin miniature DIP. This device joins others in a family that includes 25- and 35-nsec parts. $33.25 (100).

Motorola Inc, MOS Memory Products Group, Box 52073, Phoenix, AZ 85072. Phone (512) 928-6707.

Circle No 359

DRIVER IC

- *Provides dc drive to CRT horizontal-deflection transistors*
- *Provides protection during overload and power-on/off conditions*

By providing direct base drive to the horizontal deflection transistor

Ferranti's new ZN1011Q SCSI chip is already making a lot of noise with design engineers. Because it can drive up to 8 SCSI devices plus 2 sets of terminators...because it reduces board sizes and lowers costs...and because the ZN1011Q includes individually-grounded drivers for the 18 bus lines—which guarantees noise immunity. In most instances, interference is completely eliminated.

There's more. The ZN1011Q eliminates the need for external drivers, functions from a single main CPU port and assures universal host/peripheral plug compatability.

Other features include: • Conforms to current ANSI and ANSC draft proposals • Compatible with all popular microprocessors and DMA controllers • Programmable as initiator and/or target • On-chip SCSI receivers and 48mA open collector buffer drivers • Automatic SCSI handshake control • Standard SCSI connector compatible pinout • Arbitration delays defined by external clock (4 to 6MHz or 8 to 12MHz).

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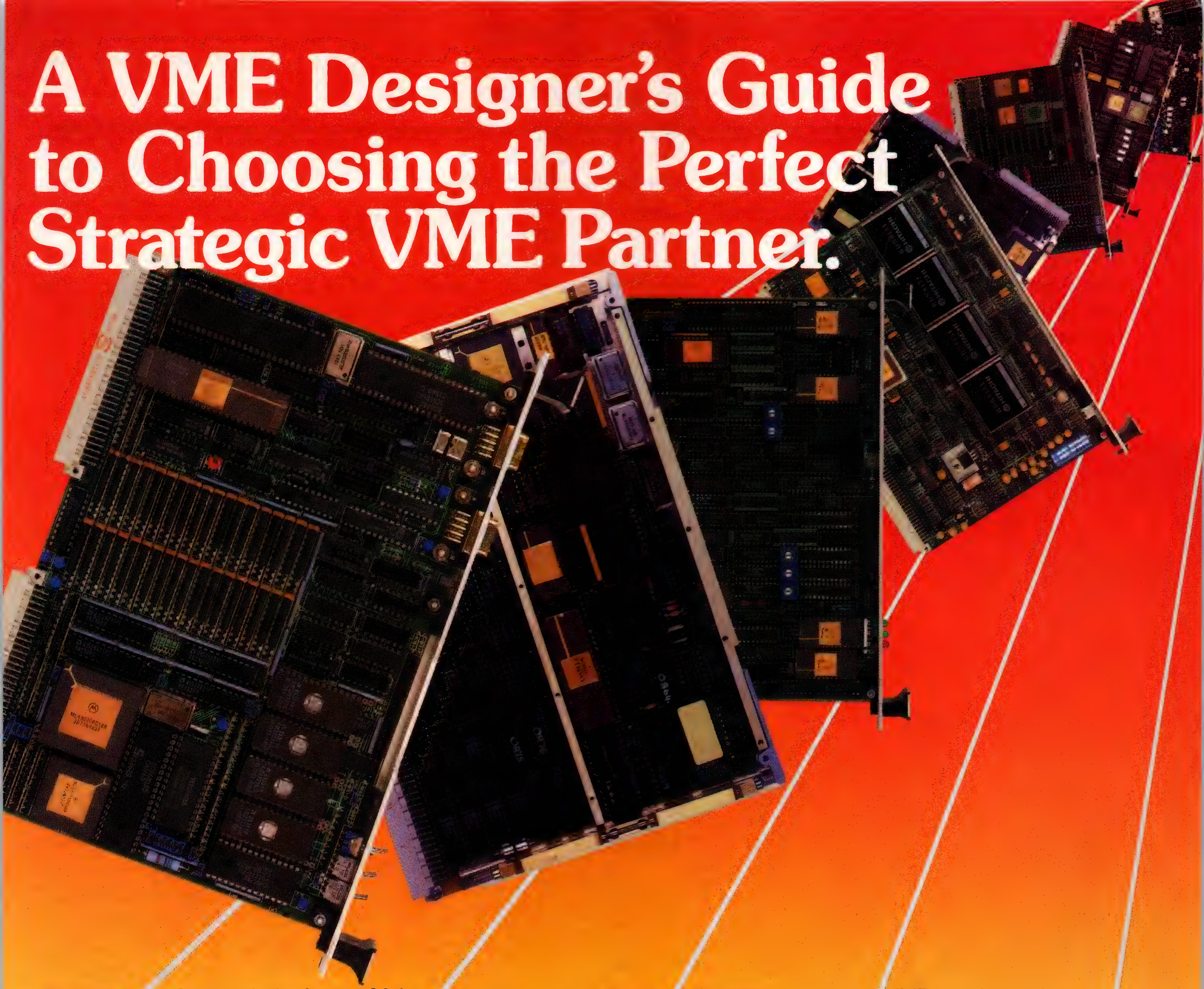
CIRCLE NO 33

A VME Designer's Guide to Choosing the Perfect Strategic VME Partner.



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CIRCLE NO 178

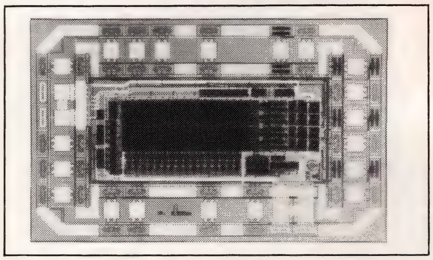
of TV and monitor CRTs, the TDA8143 driver IC eliminates the need for a separate medium-power drive transistor and a coupling transformer. The driver has a push-pull output stage, which optimizes the base drive by sensing the current flowing in the emitter of the horizontal deflection transistor. The driver also has a remote standby input to inhibit the output, and protection circuitry to protect the IC and the horizontal deflection transistor during overload and power-on/off conditions. The TDA8143 is housed in a 9-lead single-in-line package. $1.35 (10,000).

SGS Microelettronica SpA, Via C Olivetti 2, 20041 Agrate Brianza, Italy. Phone (039) 65551. TLX 330131.

Circle No 360

SGS Semiconductor Corp, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100. TLX 249976.

Circle No 361



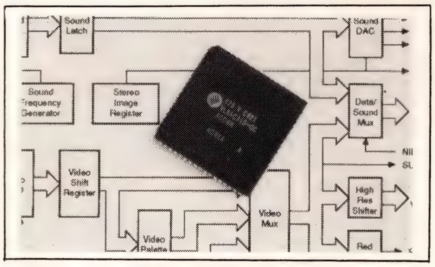
STATIC RAM

- *Provides 15-nsec access time*
- *Organized as 256×4 bits*

The VT7C122 is a CMOS, 1k-bit static RAM, organized as 256×4 bits. Specified access times are 15, 25, and 35 nsec, so the device is suitable for such high-speed applications as cache memories, writable control stores, and data-buffer memories. The manufacture of the chip is based on a 1.5-µm process. The RAM consumes 330 mW typ. It comes in a 22-pin plastic DIP. For the 15-nsec version, $10.44 (1000).

VLSI Technology Inc, 1109 McKay Dr, San Jose, CA 95131. Phone (408) 434-3100. TLX 278807.

Circle No 362



RISC CONTROLLER

- *Controls a color or monochrome display*
- *Produces multichannel sound*

The VL86C310 is a monolithic, CMOS video controller for use in the company's VL86C010 Acorn Risc

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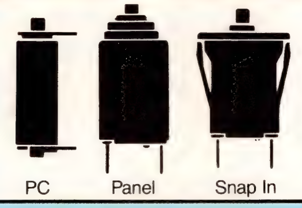

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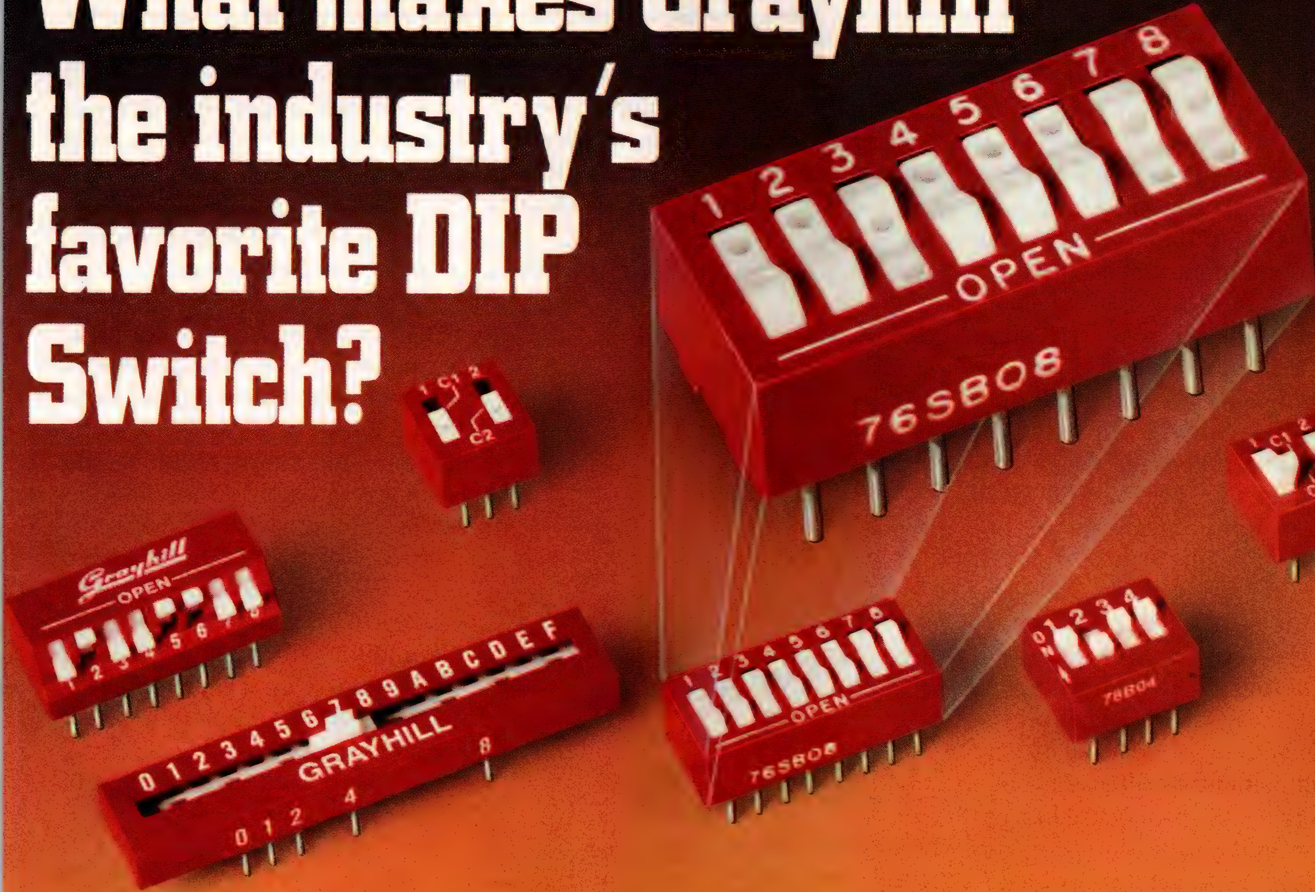

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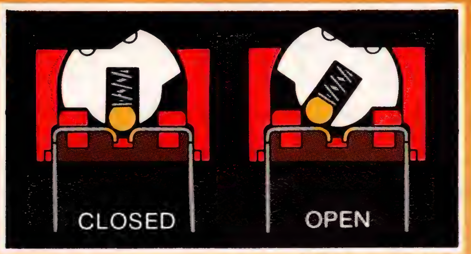

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Top performance in the field goes hand-in-hand with ease of handling in your plant:

- Bases are epoxy-sealed; optional top seal provides further protection during cleaning
- Our QC reduces yours—we do 100% electrical inspection, 100% pin straightening
- Machine insertable switches available

The Difference in Procurement...

Grayhill DIP switches are not only competitively priced, but features that are extras elsewhere are standard at Grayhill. For even greater purchasing convenience, most types are available off-the-shelf. Choose your preferred source—you can order direct from Grayhill or from your local authorized distributor.

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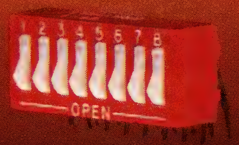

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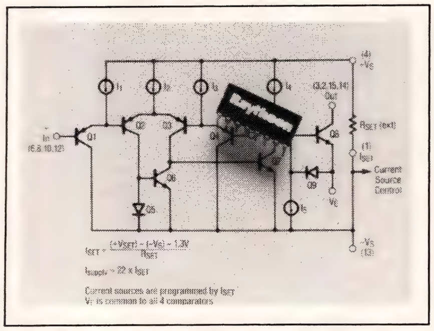
Machine. The chip fully controls a CRT and converts and formats all system information to be displayed. The device accepts feedback via a cursor or a mouse. In addition, it generates sound for as many as eight independent stereo channels at a 40-kHz sampling rate. The controller is housed in a JEDEC-standard, 68-terminal, plastic or ceramic leaded chip carrier. It accepts data under DMA control, formats and serializes it, and converts it to analog signals for driving the CRT guns. You can program an 8-, 12-, 16-, or 24-MHz pixel rate. In the 1-, 2-, and 4-bit pixel modes, the program can select any 2, 4, or 16 colors, respectively, from the 4096 colors possible, for simultaneous display on the screen. When in the 8-pixel mode the system can display 256 colors simultaneously. The chip also controls all display timing parameters and the cursor position. Three 4-bit D/A converters generate the video output. Controller in plastic package, $20.24 (1000).

VLSI Technology Inc, Application Specific Logic Products, Box 399, Lomita, CA 90717. Phone (602) 893-8574.

Circle No 363



QUAD COMPARATORS

- *Programmable supply current*
- *Output interface to various logic families*

The LP165 and -365 are quad, 139-type comparators fabricated on monolithic bipolar ICs. By adjusting a programmable set current, you can trade response time and output-drive capability for power dissipation. Each comparator has an uncommitted output-emitter connection that you can configure as an interface to TTL, DTL, CMOS, NMOS, and PMOS logic families. The comparators can operate from a single or a split power supply (4 to 36V, or ±2 to ±18V). The inputs' common-mode range includes the most negative supply rail. The devices are specified for the commercial or military temperature ranges. The package is a 16-lead plastic or ceramic DIP. Commercial version, $1.55; military, $1.93 (100).

Raytheon Co, Semiconductor Div, 350 Ellis St, Mountain View, CA 94043. Phone (415) 968-9211.

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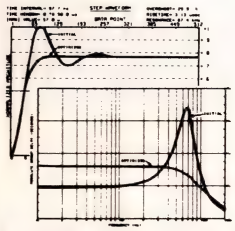

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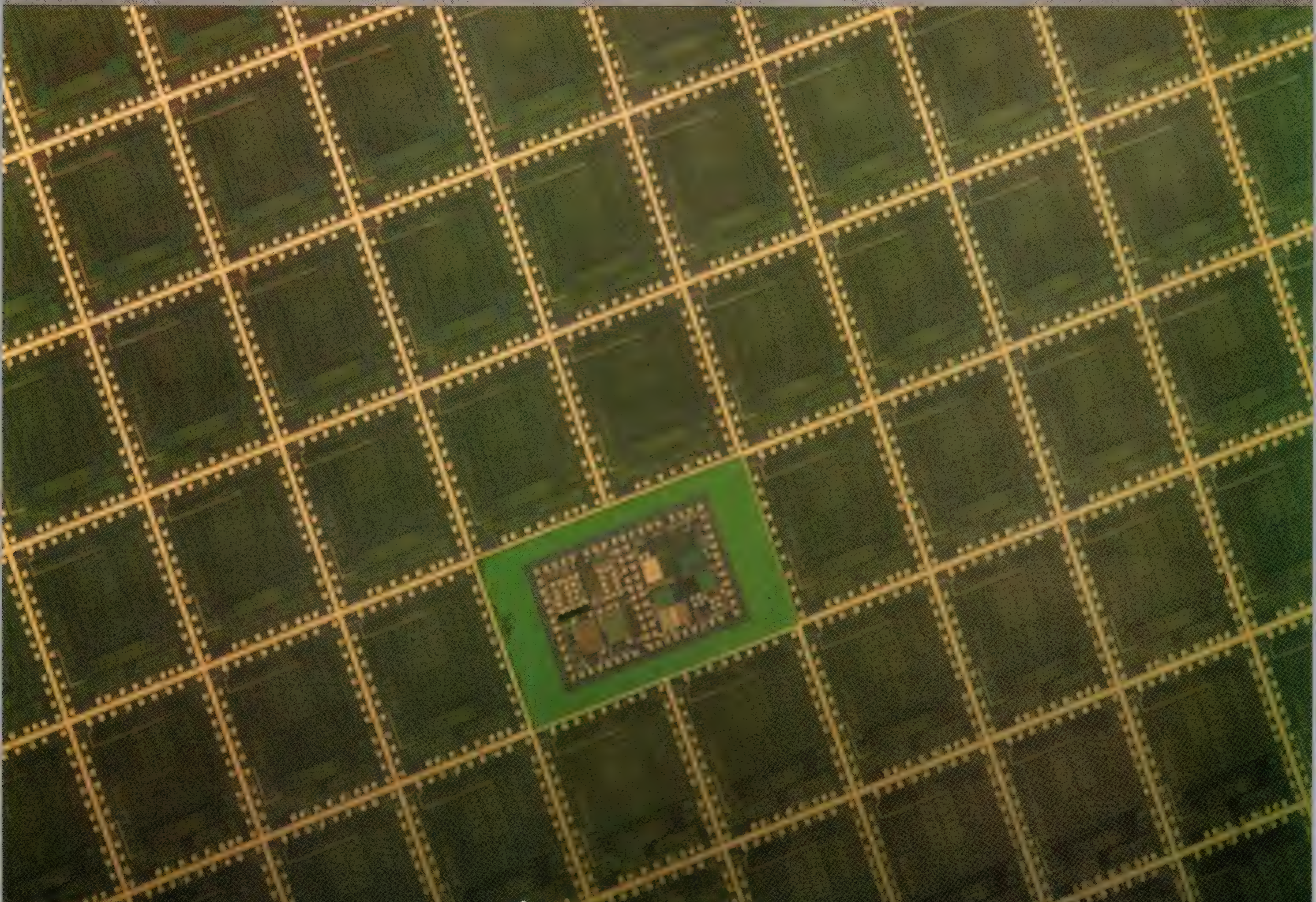

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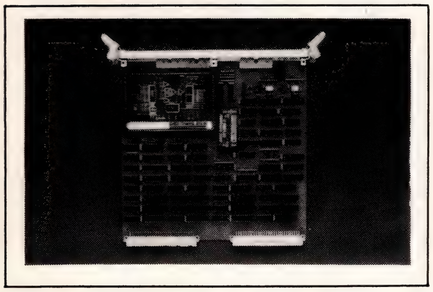
CIRCLE NO 3

NEW PRODUCTS

COMPUTERS & PERIPHERALS



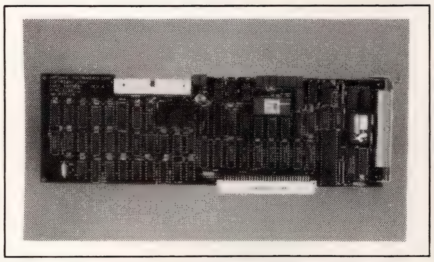
MULTIBUS II CARDS

- *Analog and digital I/O boards for Multibus II*
- *Its peak converter throughput is rated at 125 kHz*

The Dt2401 Series analog and digital I/O boards for Multibus II systems provide 12- to 16-bit resolution, throughput to 125 kHz, and programmable gain as high as 500. All models feature two 12-bit, 50-kHz D/A converters; 32 lines of digital I/O organized as two 16-bit ports; and a programmable clock that you can use to initiate A/D conversions or to control events off board. You can trigger the A/D converter via software, the onboard clock, an external frequency source, or an external trigger. $1695 to $2960.

Data Translation Inc, 100 Locke Dr, Marlboro, MA 01752. Phone (617) 481-3700. TLX 951646.

Circle No 364



I/O BOARD

- *Mac II board provides analog and digital I/O*
- *NuBus-based card includes a 12-bit A/D converter*

The NB-MIO-16 card is an analog and digital I/O board that also provides timing functions for Macintosh II applications. The board contains a 12-bit, 111k-sample/sec A/D converter that can have as many as 16 inputs; two 12-bit, voltage-output D/A converters; eight lines of TTL-compatible digital input and output; and three 16-bit counter/timers. In addition to the NuBus interface, the board provides an interface to the manufacturer's Real Time System Integration bus, which provides high-speed DMA for data acquisition and handling. The board's A/D converter operates at 25-, 15-, and 8-μsec intervals. Its two multiplying, 12-bit D/A converters provide unipolar or bipolar output. The company's Labview software supports the board. That software helps you create and interconnect virtual instruments linked by the IEEE-488 bus. By using the software with the board, you can coordinate the operation of several instruments together. $1195.

National Instruments Inc, 12109 Technology Blvd, Austin, TX 78727. Phone (512) 250-9119. TLX 756737.

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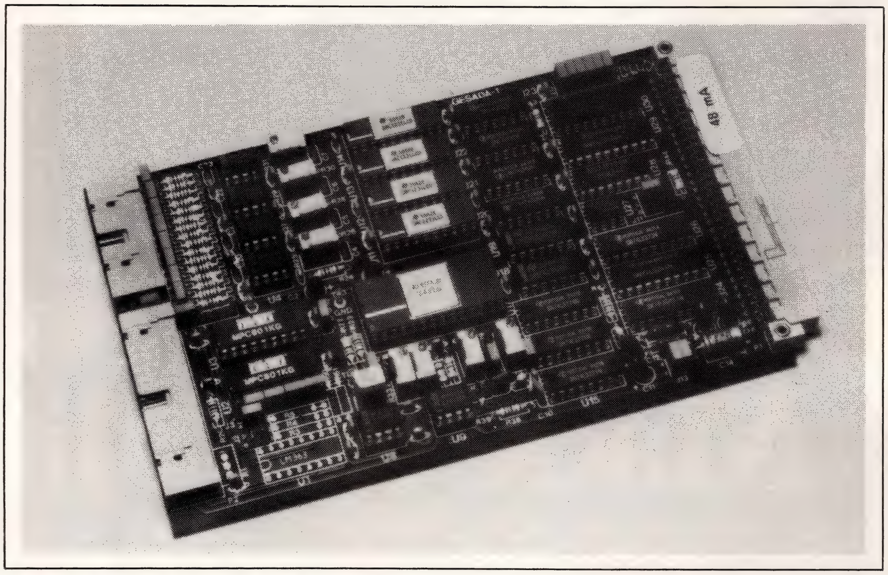

CONVERTER CARD

- *Contains A/D and D/A converters for the G-64 bus*
- *Has 10-bit resolution*

The Gesada-1A is built on a standard-height Eurocard and provides 10-bit resolution. The A/D section of the card supports 16 single-ended or eight differential input channels. You can select the analog input range of the A/D via onboard jumpers. The ranges available are ±5, ±10, and 0 to 10V. The converter uses a high-precision sample-and-hold device and an optional instrumentation amplifier to boost the gain to between 10 and 1000. The conversion time is 35 μsec. The D/A section provides four output channels, each with 10±0.25-bit resolution. You can use jumpers to select the output range, which can be either ±10V or 0 to 10V. The D/A conversion requires 4 μsec, and the maximum output current is 5 mA. $750; with instrumentation amplifier, $795.

Gespac Inc, 50 W Hoover Ave, Mesa, AZ 85202. Phone (602) 962-5559.

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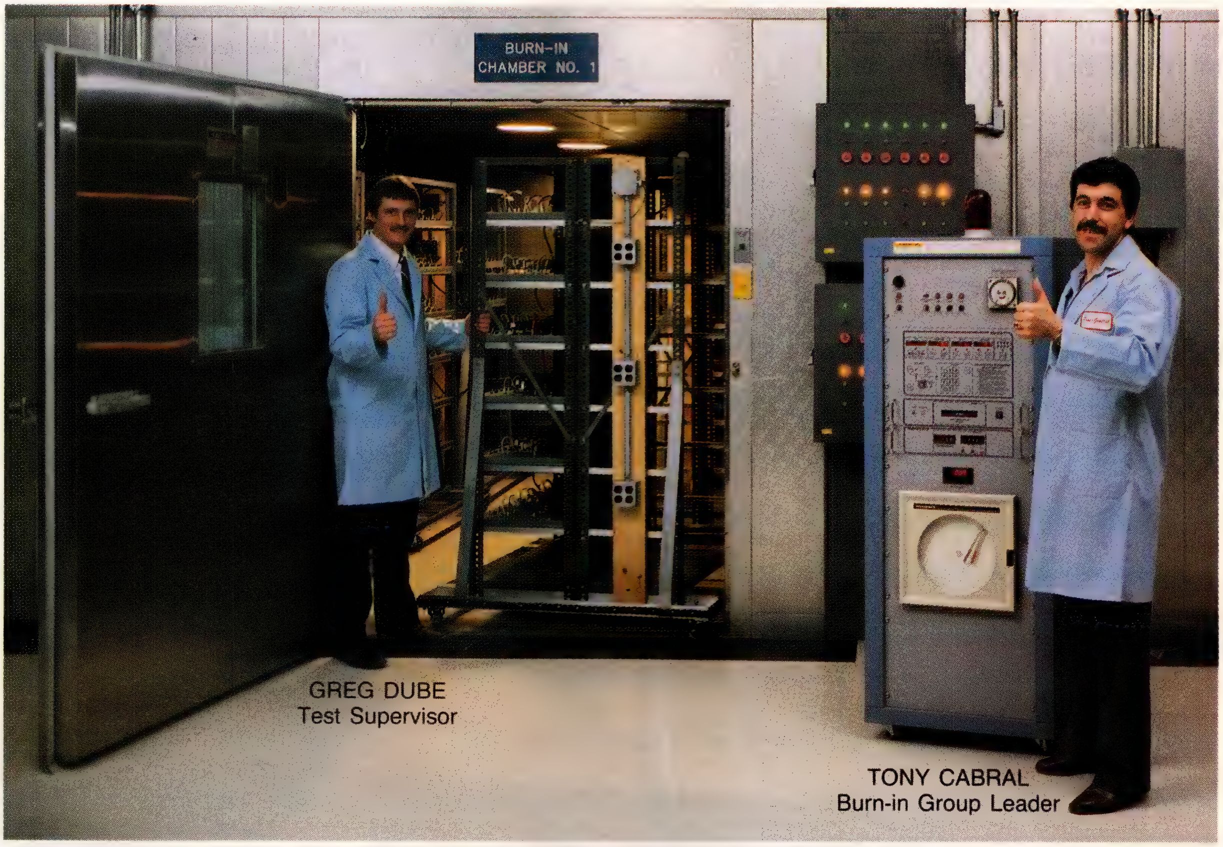

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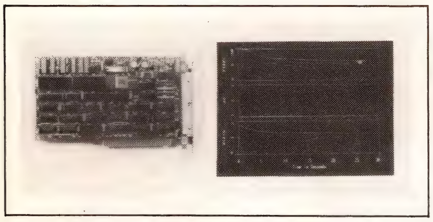

DATA ACQUISITION

- *Half-size multifunction interface for IBM PC family*
- *Data-acquisition and display software included*

The DT2811 data-acquisition board is designed for the IBM PC and offers 12-bit resolution on 16 single-ended or eight differential channels. The inputs offer 20-kHz throughput. The board also has two 12-bit analog outputs with 50-kHz throughput per channel, eight digital inputs, eight digital outputs, and a programmable clock. Interrupt support and software-programmable gains of 1, 2, 4, and 8 (for the DT2811-PGH) or 1, 10, 100 and 500 (for the DT2811-PGL) are standard. DT2811-PGH, $745; DT2811-PGL, $845.

Data Translation Inc, 100 Locke Dr, Marlboro, MA 01752. Phone (617) 481-3700. TLX 951646.

Circle No 367

DISPLAY CONTROLLER

- *Supports resolution of 2048×1536×8 bits*
- *Fits into one slot in an IBM PC/AT*

The UDC-800 is a high-resolution display controller that fits into a single slot in an IBM PC/AT. At 2048×1536 pixels and 8 bits per pixel, the card supports the highest resolution displays available. Those displays, with a 60-Hz noninterlaced rate, require video display rates in excess of 200 MHz. The controller achieves that signal rate by using 3M bytes of dual-ported video RAM and ECL shift registers. As much as ½M byte of RAM can be dedicated to display lists. The RS-343 video output offers composite or separate synchronization. You can attach an optional UPX-1000 coprocessor by using the board's VSB Bus interface. Graphics-standard interfaces, including VDI, GKS, and NAPLPS, are available as options. $6995.

Univision Technologies Inc, 12 Cambridge St, Burlington, MA 01803. Phone (617) 273-5388. TLX 988755.

Circle No 368

COPROCESSOR BOARD

- *Lets you run DOS software on the VME Bus*
- *Provides simultaneous access to Unix and DOS files*

The VMEx286 coprocessor, in conjunction with the DOS/Emulator

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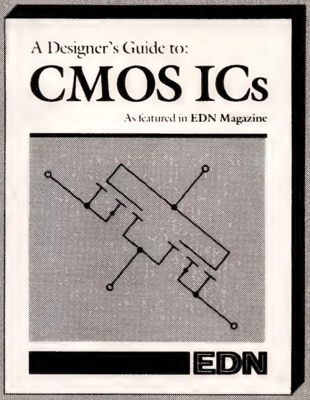

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For details on VLDS, and its OEM pricing, contact Tom Balue, Honeywell Test Instruments Division, Box 5227, Denver, CO 80217-5227. (303) 773-4491.

Together, we can find the answers.

Honeywell

CIRCLE NO 37

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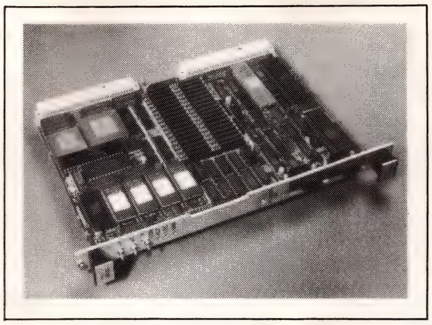
(from Emulator Co, Berkeley, CA), gives Unix users access to DOS applications and development software. This facility allows you to log on to the Unix system and use the emulator to run DOS programs. The board has 512k bytes of dual-ported memory and an 80286 that operates at 8 MHz. Because you can access Unix files directly through the DOS/Emulator, no file transfers are necessary. VMEx286, $2280.

Iskra VME Technologies, 222 Sherwood Ave, Farmingdale, NY 11735. Phone (516) 753-0400. TLX 221527.

Circle No 369



BOARD COMPUTER

- *Provides a 68020 and as much as 4M bytes of local RAM*
- *Includes VME Bus system-controller functions*

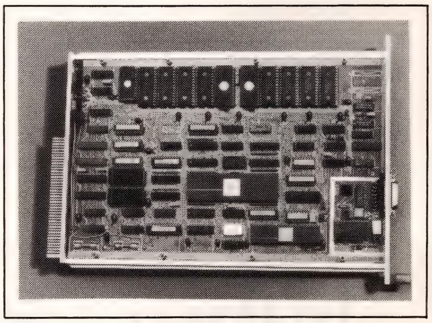
The PME 68-23 single-board computer for VME Bus systems has a 68020 μP and as much as 4M bytes of 32-bit local RAM. The vendor offers an optional 68881 math coprocessor. Four EPROM sites allow you to load the board with as much as 512k bytes of firmware. The board also has 2k bytes of static RAM that you can back up via the VME Bus 5V standby supply line. The board also includes a real-time clock/calendar, three 8-bit programmable timers, and a 24-bit counter with a 5-bit prescaler. Its I/O facilities include three serial I/O ports and 8- and 16-bit bidirectional parallel I/O ports. The interrupt facilities include a mailbox interrupt for message passing. The board's VME Bus interface supports 32-bit VME Bus addressing and data transfers, and it includes system-controller functions and a 7-level bus-interrupt handler. You can disable the system-controller functions if they're not required. From £1295 to £2695.

Plessey Microsystems Ltd, Water Lane, Towcester, Northants NN12 7JN, UK. Phone (0327) 50312. TLX 31628.

Circle No 370

Plessey Microsystems Inc, One Blue Hill Plaza, Pearl River, NY 10965. Phone (914) 735-4661. TWX 710-541-1512.

Circle No 371



ETHERNET INTERFACE

- *Interfaces CAMAC systems to IEEE-802.3 LANs*
- *Has onboard 68000 μP and buffer memory*

The VTC-710, a single-width interface card for CAMAC systems, transfers data between the CAMAC system and an Ethernet (IEEE-802.3) local-area network. The interface is controlled by an onboard 10-MHz 68000 μP, which comes with 64k bytes of 120-nsec RAM for data buffering and 64k bytes of firmware space. A DMA unit, which includes a byte-swap facility, handles data transfers between the local RAM and the CAMAC bus. The Ethernet node address resides in an onboard PROM. The card comes with driver software, which gives you a standardized method of accessing the Ethernet network

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GBL GigaBit Logic

PicoLogic™ Digital ICs	Part No.	Speed	Availability
Gates			
Quad 3 Input NOR	10G000A	290 ps	In Stock
Quad 2 Input NOR	10G001	290 ps	In Stock
Quad Differential XOR/XNOR and Line Receiver	10G002	1.8 GHz	In Stock
5, 4, 3, 2/3, 2 Input AO/AOI	10G003	600 ps	4 weeks ARO
Drivers/Receivers/Comparators			
Dual Complementary Driver/Comparator	10G012B	1.8 GHz	In Stock
Dual 4:1 Fanout Buffer	10G011B	700 ps	In Stock
Dual Differential MUXed Fanout Buffer	10G010	1.5 GHz	In Stock
Flip Flops and Registers			
Dual Precision D Flip Flop	10G021A	2.7 GHz	In Stock
Quad MUXed Input D Flip Flop	10G023	2 GHz	In Stock
Quad XOR Input Flip Flop	10G024	2 GHz	In Stock
Octal Register/Shift Register and PN Code Generator	10G022	1.5 GHz	In Stock
Register Files			
16 x 4 3-Port Register File	10G030	1 ns	6 weeks ARO
Multiplexers/Demultiplexers			
Quad 4:1 or Dual 8:1 MUX	10G046	600 ps	In Stock
Quad 2:1 MUX	10G004	1.8 GHz	In Stock
3:8 or Dual 2:4 Decoder/DEMUX	10G044	700 ps	In Stock
Counters/Prescalers			
2-Stage Divider	10G060	2.5 GHz	In Stock
4-Bit Synchronous Programmable Counter	10G061	1.6 GHz	In Stock
7-Stage Counter/Divider	10G065	3.0 GHz	In Stock
Variable Modulus Divider	10G070	2.0 GHz	In Stock

PicoLogic™ Digital ICs	Part No	Speed	Availability
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Ultra-High Speed 4-Bit Adder	10G100	800 ps	In Stock
Ultra-High Speed Carry Lookahead	10G101	500 ps	In Stock
4-Bit ALU (10181 ECL equivalent)	10G181	2 ns	6 weeks ARO
Monolithic FET and Diode Arrays			
15 mA Diode Array	16G010	—	In Stock
100 mA Diode Array	16G011	—	In Stock
Single Gate FET Array	16G020	15 GHz	In Stock
Dual Gate FET Array	16G021	15 GHz	In Stock
NanoRam™ Memory			
256 x 4-Bit Pipelined Static RAM	12G014	3 ns cycle time	Production Sampling
Communication Products			
8:1 Time Division MUX	10G040	1.5 Gb/s	In Stock
1:8 Time Division DEMUX	10G041	1.5 Gb/s	In Stock
Clock and Data Recovery Circuit	16G040	2.0 Gb/s	In Stock
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Phase Frequency Comparator	16G044	1.0 GHz	In Stock
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SC-1 Standard Cell Library	80 GSC1	—	Available
Foundry Program	—	—	Available
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Universal Prototype Board	90GUPB	—	In Stock
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CIRCLE NO 181

without requiring detailed knowledge of the interface hardware. £1290.

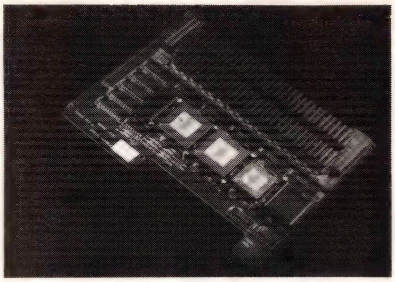
Vertec Ltd (Electronics), Maxwell Building, 43 The Crescent, Salford, Manchester M5 4WT, UK. Phone 061-736-8502. TLX 668680.

Circle No 372

ACCELERATOR

- *Boosts performance of Macintosh SE*
- *Includes 16-MHz, 32-bit μP*

The Prodigy SE coprocessor boosts the performance of the Macintosh SE by two orders of magnitude. It includes a 16-MHz 68020, 1M byte of RAM, a nonvolatile RAM disk, and two expansion ports. The expansion buses include a 32-bit memory bus and a 16-bit I/O bus. You can add a 16-MHz 68881 floating-point coprocessor; 2M, 4M, or 8M bytes of memory; and a paged memory-management unit (MMU). You need the MMU for memory configurations of greater than 4M bytes; the unit can support as much as 32M bytes. An external, large-screen monitor and a 40M-byte hard-disk drive are also available. The board uses the standard Macintosh operating system and is compatible with Macintosh software. $1995; $350 each for the 68881 and the 2M-byte memory expansion.



Levco, 6160 Lusk Blvd, Suite C-203, San Diego, CA 92121. Phone (619) 457-2011.

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CIRCLE NO 40

AXIS CONTROLLER

- *Provides 4-axis positional control*
- *Includes firmware for proportional and PID control loops*

The TSVME440 is a double-Eurocard VME Bus board that provides intelligent control for 4-axis positional-control systems that use dc motors. The board uses four 13-bit, ±10V outputs to control the motors, and it has corresponding inputs for four linear or rotational incremental encoders with 32-bit resolution. The board also has four auxiliary 8-bit, ±10V analog inputs and outputs, eight 12 to 24V optoisolated digital outputs, and sixteen 12 to 24V optoisolated digital inputs. The board is equipped with a 12.5-MHz 68010 μP, space for as much as 128k bytes of EPROM firmware, and 64k bytes of zero-wait-state RAM. For stand-alone operation, you can control the board via either of two RS-232C serial I/O ports. The board comes with firmware for proportional and PID (proportional integral and differential) control loops, VME Bus and terminal communication, and system monitoring and debugging. Approximately Fr fr 23,000.

Thomson Semiconducteurs, 45 Ave de l'Europe, 78140 Velizy, France. Phone (1) 39469719. TLX 204780.

Circle No 374

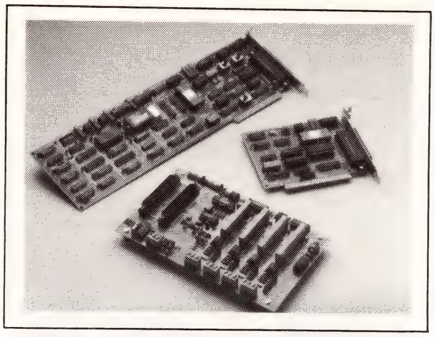
Thomson Components-Mostek Corp, 7950 E Redfield Rd, Scottsdale, AZ 85260. Phone (602) 951-2900.

Circle No 375

COMPUTER

- *Single-board computer contains 68020*
- *VME Bus-compatible CPU comes in single-height format*

The VMPM68KC single-board computer for the VME Bus features a 68020 that operates at either 12.5 or 16.7 MHz. The single-height VME



MUX

- *Expansion multiplexer for analog input boards*
- *As many as 128 isolated inputs attach to analog I/O boards*

Using the ISO-4 isolated expansion multiplexer, you can attach 128 isolated inputs to the company's DAS-CON-1, DAS-8, or DAS-16F analog input boards. Using 4 output bits, one of the A/D boards selects which ISO-4 of the attached ISO-4 boards it will monitor, and which channel it will monitor. Each input is isolated from the other inputs as well as from the A/D board. An instrumentation amplifier on each input provides gains from 1 to 1000. The board includes a cold-junction temperature sensor that provides an input signal of 24.4 mV/°C. When coupled to a 12-bit A/D converter with 10V full scale, this input corresponds to 10 bits/°C. $750.

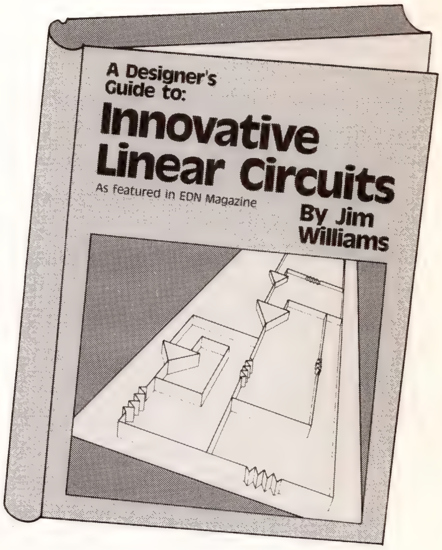
Metrabyte Corp, 440 Myles Standish Blvd, Taunton, MA 02780. Phone (617) 880-3000. TLX 503989.

Circle No 378

ANALOG I/O CARD

- *Provides 12-bit analog inputs and outputs*
- *Has onboard 80186 μP*

The CESA-2/01 is an analog I/O board for Multibus II computer systems. You can configure the board to have 64 single-ended or 32 differential analog input channels with 12-bit A/D conversion on each channel. You can program the A/D converter to operate with full-scale ranges of 0 to 5V, 0 to 10V, ±2.5V, or ±5V. You can program the board's front-end programmable gain amplifier to have a gain of ×1, ×2, ×5, or ×10. By selecting appropriate jumper links, you can multiply these gain values by 1, 4, or 10. If you don't change the input channel or gain value, you can achieve a speed as high as 100k conversions/sec. In addition, the board has four 12-bit analog outputs for which you can select full-scale ranges of 0 to 5V, 0 to 10V, ±2.5V, ±5V, or ±10V. The board includes an 80186 μP and six 28-pin sockets that you can load with as much as 128k bytes of RAM or 256k bytes of EPROM. It also sports two SBX-bus connectors and an RS-232C serial I/O channel. The board's Multibus II interface utilizes the message-passing coproc-



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essor and provides built-in self-testing. CSM (central services module) functions are optional. Approximately Fr fr 19,500.

Efisysteme, La Boisse, 01120 Montluel, France. Phone 78062155. TLX 305551.

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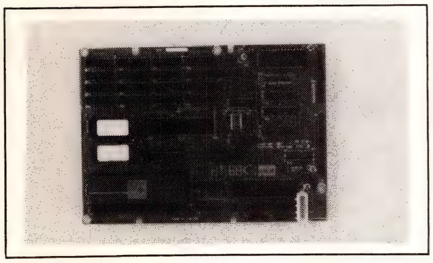


COMPUTER

- *Single-board computer is based on 68000*
- *Includes debug-monitor and boot-up software*

The HT-68k TinyGiant single-board computer includes a 68000 CPU that operates at 8 MHz; 128k bytes of no-wait-state RAM that's expandable to 512k bytes; and a 64k-byte EPROM. The board also contains a floppy-disk-drive controller capable of controlling four 5¼-in. or 3½-in. floppy-disk drives. The operating system reads from and writes to MS-DOS-formatted disks. The board also contains a parallel printer port and two RS-232C ports, which have independent baud rates of 50 to 38.4k baud. The card measures 5.75×8 in., which is the same size as a disk drive for 5¼-in. floppy disks. You can mount the board on the side of a disk drive. $395.

Hawthorne Technology, 8836 SE Stark, Portland, OR 97216. Phone (503) 254-2005.

Circle No 380

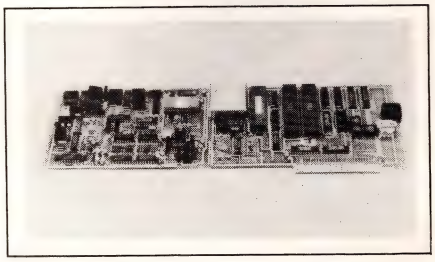
NETWORK

- *Adapter board for IBM PC*
- *Connects PC to StarLAN network*

The StarCard Plus provides a network station interface between an IBM PC and the 1M-bps StarLAN network. The computer connects, via the StarCard, at any StarLan-compatible hub. The PC can access the board's dual-ported 8k-byte memory directly (no PC DMA channels are necessary). The manufacturer provides software interfaces for the Vianet operating system and for Advanced Netware. The NetBIOS/OSI is also available to support applications such as Microsoft's MS-NET and the IBM PC Network Program. The board requires a half slot and operates in PCs having clock rates as high as 16 MHz.

Western Digital Corp, 2445 McCabe Way, Irvine CA 92714. Phone (714) 863-0102. TWX 910-595-1139.

Circle No 381



PC FAX

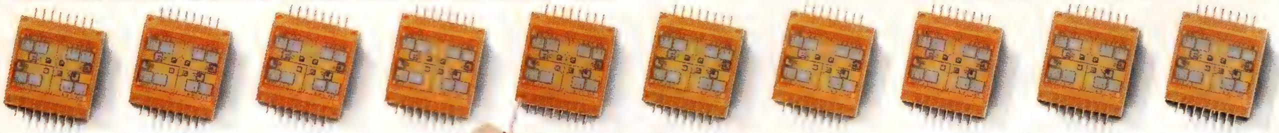
- *Interface between IBM PC and phone lines*
- *PC users can send or receive stored images*

The PC ImageFax board is a PC- and PC/AT-compatible card for transmitting captured images over phone lines. The card receives and transmits images that are compatible with a variety of telephone transmission formats, including AP AM, CCITT FM and AM, UPI FM and AM, GOES AM, GMS AM, and METEOSTAT AM. $1900.

Leaf Systems Inc, Box 8240, Natick, MA 01760. Phone (617) 651-9715.

Circle No 382

A HYBRID IS A HYBRID .... NOT TRUE



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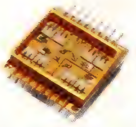

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SHARP Scientific calculator EL-506P
hp 16C
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The Casio fx-7000G $79.95. It's the world's first programmable scientific calculator with a graphic display. The only calculator that can give form to your figures, instantly drawing graphs that represent your formulas and calculations on its big LCD screen.

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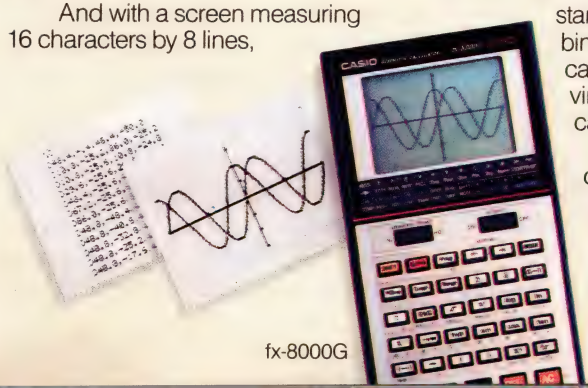
If you have any doubt as to who's the leader in high-tech calculators, simply pick up an fx-7000G or fx-8000G and draw your own conclusions.



fx-8000G

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Casio, Inc. Consumer Products Division: 15 Gardner Road, Fairfield, N.J. 07006
New Jersey (201) 882-1493, Los Angeles (213) 803-3411

COMPONENTS & POWER SUPPLIES

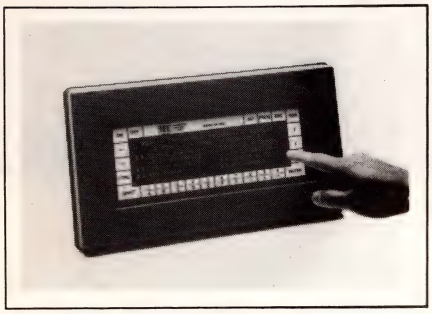
SWITCH-CORE ARRAYS

- *Available in sealed and open constructions*
- *Closed-switch capacitance values range to 700 pF*

Compatible with elastomeric and conventional spring-plunger systems, these capacitive switch-core arrays function as the switching element in full-travel keyboards. The arrays are available in both sealed and open constructions. Closed-switch capacitance values range to 700 pF. Along with an open-switch value as low as 2 pF, the high closed-switch capacitance significantly simplifies key-closure decoding circuitry. The life cycle for the sealed systems exceeds 10^8 switch activations. The switch cores are available in sealed and open constructions. $0.04 to $0.09 per switch for a 100-position array.

W H Brady Co, Xymox Div, Box 571, Milwaukee, WI 53201. Phone (414) 355-8300.

Circle No 383



DISPLAY MODULE

- *Software-controlled brightness*
- *CMOS RAM stores canned messages*

The 4283-01 integrates a 6-line×40-character vacuum-fluorescent (VF) display with an IR touchscreen. Each of its blue-green, 5×7 dot-matrix characters is 5 mm high. The display has three software-controlled brightness levels (ranging to 185 fL) and 8k bytes of CMOS RAM, which can store as many as 127 user-programmable messages. The display's onboard battery backup retains the messages even after you turn off the power. An onboard µP controls all display and touch-input operations, a self-diagnostic test program, and a serial data interface with your host computer. The host connection can be RS-422 or RS-232C with CTS (clear to send) and DTR (data terminal ready) signals. The module operates from a 5V supply. From $800 (100).

Industrial Electronic Engineers Inc, 7740 Lemona Ave, Van Nuys, CA 91409. Phone (818) 787-0311. TLX 4720556.

Circle No 384

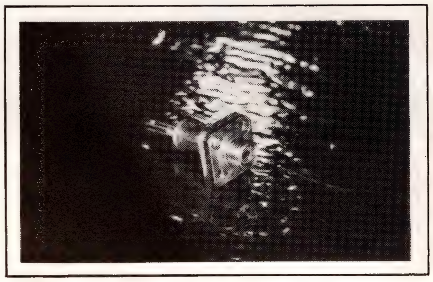
OPTOCOUPLERS

- *Feature 5000V pk electrical isolation*
- *Include a Schmitt trigger stage*

OP18012 Series optocouplers are for applications requiring as much as 5000V pk electrical isolation. The units integrate a GaAs LED, a photodetector, an amplifier, and a Schmitt trigger stage, and they provide a digital output. Four output options are available: the OP18012, with a buffer totem-pole output; the OP18013, with a buffer open-collector output; the OP18014, with an inverter totem-pole output; and the OP18015, with an inverter open-collector output. The devices' outputs are compatible with TTL/LSTTL. All units spec a 200k-baud data rate, a fanout of eight TTL loads, and an operating range of −40 to +70°C. The UL-recognized units are housed in 6-pin plastic DIPs. $1.42 (100).

Texas Instruments Inc, Semiconductor Group, Box 809066, Dallas, TX 75380. Phone (800) 232-3200.

Circle No 385



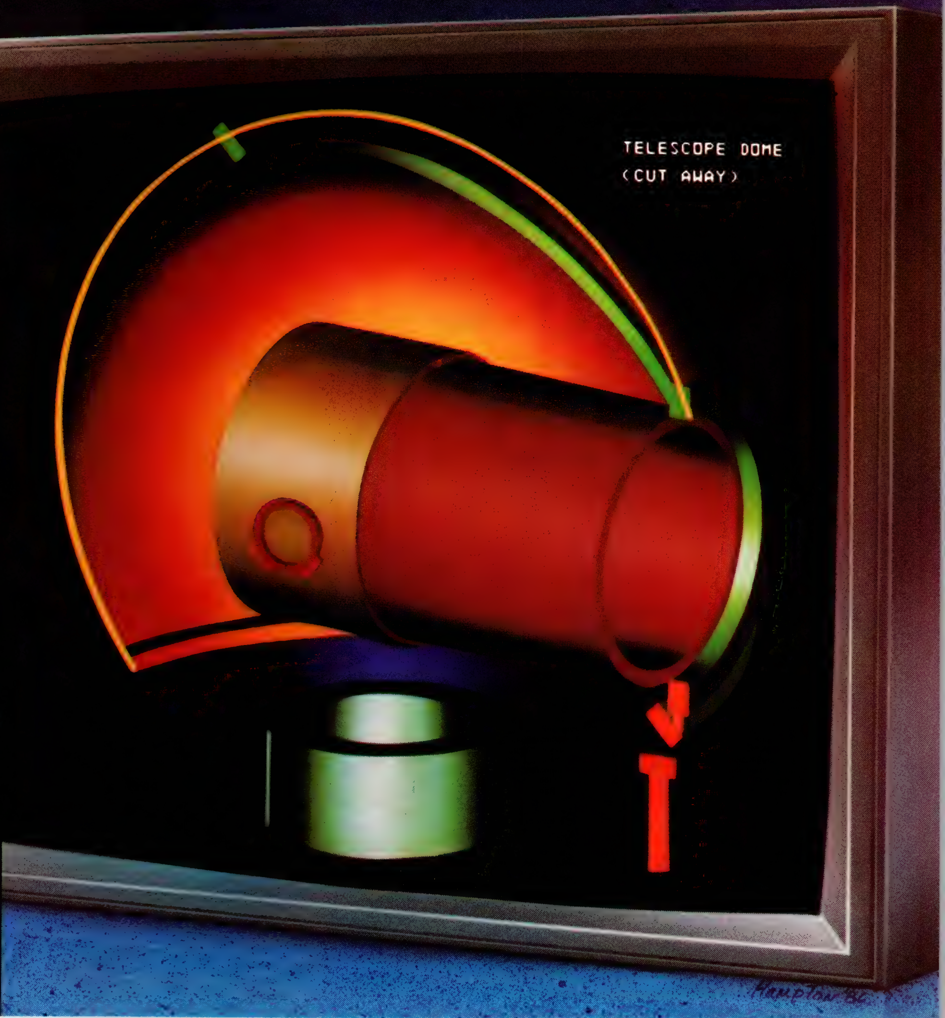
LASER MODULE

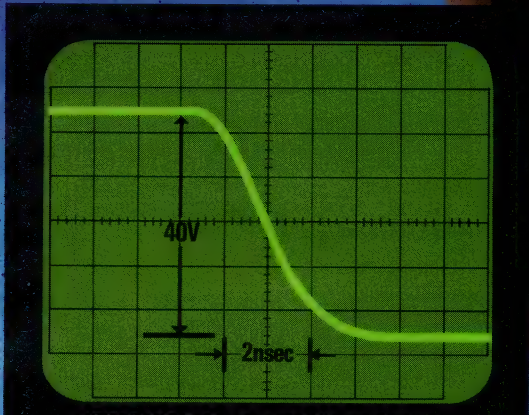
- *Housed in a connector-type module for easy installation*
- *5×10^7-hour MTBF*

Featuring a 1300-nm output wavelength, the FU-11SLD-N single-mode laser module comes in a connector-type housing that eases system installation. Four electrical connections provide isolated access

New from TRW...

A 130MHz Hybrid Video Amplifier for Ultra High Resolution.





CR2424 Output Waveform

The most cost effective video driver on the market today!

Applications that require ultra-high resolution graphics have been limited — up to now — because of the speed of their video amplifiers. This new hybrid from TRW RF Devices overcomes that limitation. It provides . . .

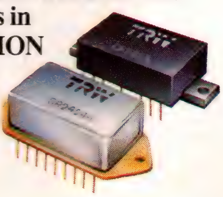
- 130MHz minimum bandwidth at 40V swings
- 2.5nsec typical rise and fall times at full output
- 15,000 volts/μsec slew rate
- Low power consumption — typically less than 3W

And this new hybrid — the CR2424 — is easy to use. It drives capacitive loads directly or through transmission lines, with no output tuning and no need for critical external components.

The CR2424 is priced, in quantities over 5000, at only $15.00 — significantly lower than the price of other amplifiers that cannot match this one in resolution or speed.

In addition to a broad range of commercial applications, this product is also available in a hermetic package that meets MIL Std. 883 requirements.

Look to TRW RF DEVICES for the latest developments in HIGH-RESOLUTION TECHNOLOGY.



For further information, for assistance with your particular requirements, for the location of your nearest distributor, contact your local TRW ECG Field Sales office or call Matthew Hartwig, Sales Engineer CRT Devices:

RF Devices Division
TRW Electronic Components Group
14520 Aviation Boulevard
Lawndale, CA 90260, 213.536.0888

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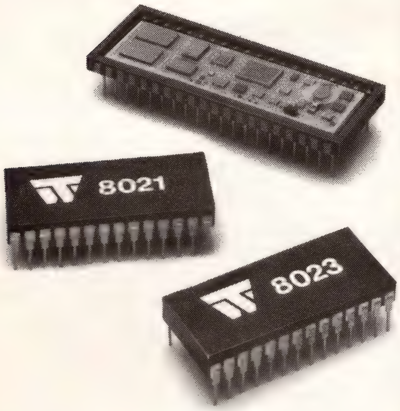
TRW

RF Devices Division
TRW Electronic Components Group

CIRCLE NO 183



125°C & 200°C

New Hot Hybrids from White.

When you need Hybrids that can take the heat, give us a call. We have devices for almost every design and design environment. And, they're available in Military or High-Temp versions, in ceramic, hermetic metal DIPs or flatpacks, and in single quantities or thousands. Same great performance, realistic pricing, and on-time delivery.

Here are just a few!

- **8kx8, 16kx8, and 64kx8 STATIC RAMS**
  Burned-in and fully tested at 200°C, 150nSec access time, 5mA operating current.
- **2kx8, 8kx8, 32kx8, and 64kx8 PROGRAMMABLE CMOS EEPROMS**
  Three-State output, reprogrammable up to 180°C, and can be read at temps thru 200°C. Internal temp compensation, 250nSec access time @ 200°C.
- **16-BIT MICROCOMPUTER SYSTEM**
  Complete, stand alone 8088-based system in a 40-pin package. Low power, onboard crystal oscillator, 16 Kbytes of both CMOS EEPROM and CMOS RAM, and a serial communications port. PC written software easily debugged and downloaded. Expandable to 1 Mbyte.

Call now, or write for details.
Remember, we speak fluent hybrid.

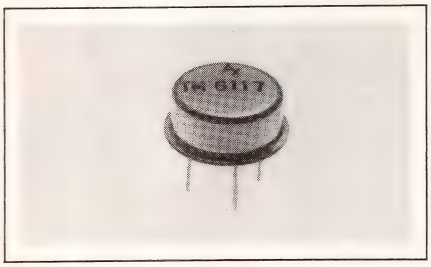
Bowmar/White Technology
4246 E. Wood Street • Phoenix, Arizona 85040
(602) 437-1520 • TWX 910-951-4203

CIRCLE NO 45

to the InGaAs laser diode and the back-facet monitor photodiode. The MTBF at 25°C specs at 5×10^7 hours. Threshold and operating currents equal 20 and 45 mA, respectively, and the operating range spans −20 to +60°C. $600 (100). Delivery, six to eight weeks ARO.

Mitsubishi Electronics America Inc, Semiconductor Div, 1050 E Arques Ave, Sunnyvale, CA 94086. Phone (408) 730-5900.

Circle No 386



RF AMPLIFIER

- *Meets MIL-STD-883B screening*
- *10- to 250-MHz bandwidth*

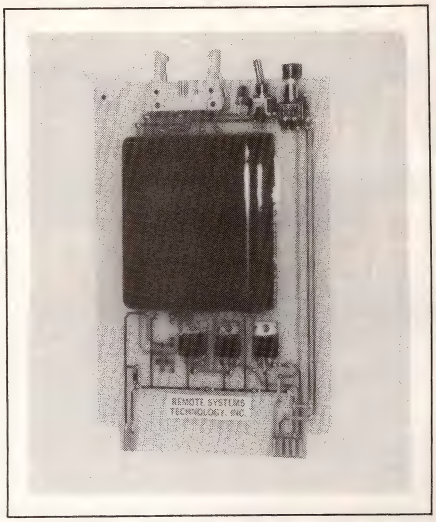
The Model TM 6117 hybrid RF amplifier provides an 8-dB typ gain over 10 to 250 MHz. Other specifications include a 1.6-dB typ noise figure, 10 dBm of output power at the 1-dB compression point, and input and output VSWRs of 2:1. The power requirements are 15V at 12 mA, and the operating range spans −55 to +85°C. All units meet MIL-STD-883B screening. The amp is housed in a hermetic TO-8 can. $81.

Amplifonix Inc, 2010 Cabot Blvd W, Langhorne, PA 19047. Phone (215) 757-9600.

Circle No 387

POWER SUPPLIES

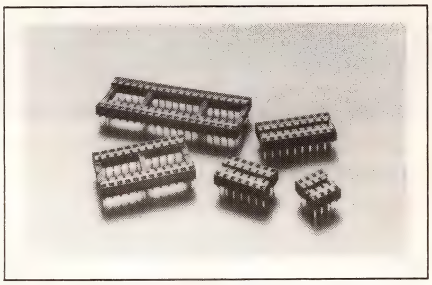
- *Plug into STD Bus backplane*
- *Available with ac or dc inputs*



Series 29 power supplies plug directly into STD Bus card-cage connectors. The supplies are available with inputs of 12, 24, and 48V dc, and 120 and 240V ac. Standard outputs are 5V at 1.5A (to the STD logic Bus) and ±12V at 300 mA (to the STD auxiliary bus). An output of −5V at 250 mA is optional. All outputs feature overvoltage protection. The series' efficiency specs at 78% min. All models include a system-reset pushbutton, an on/off switch, and an LED power-on indicator. You can operate the supplies at temperatures as high as 80°C without derating. The boards come with either a flat cable connector or a terminal block. $240. Delivery, stock to six weeks ARO.

Remote Systems Technology Inc, 1800 West Belt N, Houston, TX 77043. Phone (713) 932-9584. TLX 882267.

Circle No 388



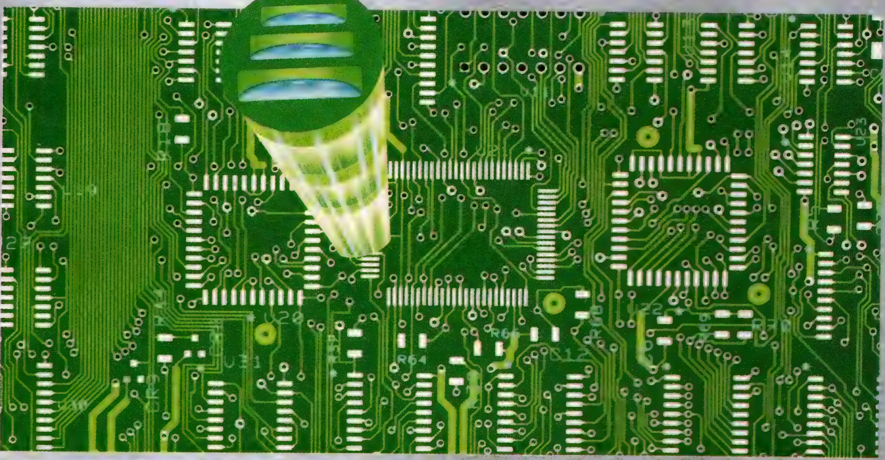
DIP SOCKETS

- *Available in a choice of contact materials*
- *Contacts sealed in a UL 94V-0 glass-filled polyester body*

The FSWP/FSWB single-beam antiwicking sockets are available with either phospher-bronze or beryllium-copper contacts in sizes ranging from 8 to 40 positions. The

TAKE A CLOSER LOOK AT ADDITIVE'S SURFACE MOUNT CIRCUITS

The advantages of additive Surface Mount Circuits save time and money for users, give higher first-pass yields and totally predictable results. Here's why:



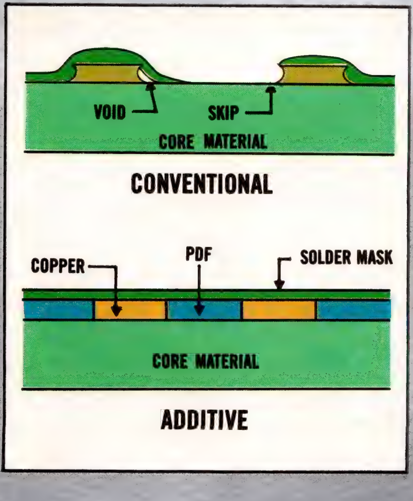
IN A NUTSHELL, ADDITIVE SMC's GIVE YOU:

- The highest density circuitry available (down to 0.003").
- Totally predictable geometries and electrical properties.
- Near-flush surfaces for trouble-free device placement.
- Pad side wall encapsulation equivalent to a perfectly registered soldermask for bridgeless soldering.
- Optional Micro-socket™ soldermask for hi-rel solder joints even on super-high pin count devices.
- Micro-bond™ pad and trace adhesion to "open-up" the repairability process window.
- Optional copper or soldercoated pads.
- The highest "first-pass" yield opportunity in assembly.

Send for complete information on SMC's or any Additive product.

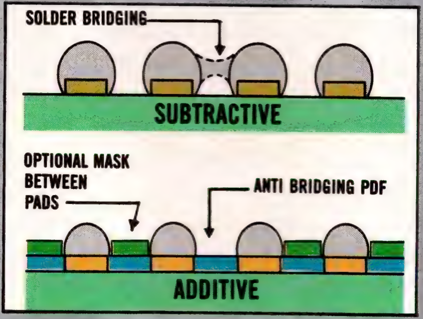
Better basic construction

The dielectric used to define lines/spaces (down to 0.003 inches) totally encapsulates conductor and pad sidewalls, and provides a near-flush surface for trouble free component mounting and soldering. Ideal for *all* surface mount devices from simple chip passives to "super-high" pin count PLCC's and Quads, and all common surface mount assembly, repair and cleaning processes. Hi-rel micro-vias, (0.010" diameter min.), allow routing density beyond conventional capabilities.



SMOBC with Micro-socket™ option

A near-flush conductor surface allows uniform and precisely registered permanent Solder Mask Over Bare Copper without skips, smear, bleed, or adhesion loss, simplifies glue and/or solder paste application. A Micro-socket™ soldermask option eliminates pad to pad bridging (even on 0.020" pitch, leaded chip carriers) even when more solder is applied to avoid "missed" joints and improve reliability.



Trouble-free component repair

Unlike pad and trace "lifting" problems of conventional etched circuitry, Additive's new Micro-bond™ SMT surface allows soldering iron rework without adhesion failure.

EVERY ADDITIVE PRODUCT IS A PLUS FOR YOU

ADDITIVE PRODUCTS DIVISION
KOLLMORGEN CORPORATION
P.O. Box 700 Aquebogue, NY 11931

Please send me detailed information on:
☐ SMT (Surface Mount) seminars in my region, sponsored by APD
☐ PDF (High Density) Circuits
☐ CPF (Precious Metal Replacement) Circuits
☐ SMC (Surface Mount) Circuits
☐ ALC (Add-A-Layer Multilayer) Circuits

NAME ______________________ (Job Title)

COMPANY ______________________

ADDRESS ______________________

CITY __________ STATE __________ ZIP __________

EDN052887

CIRCLE NO 184

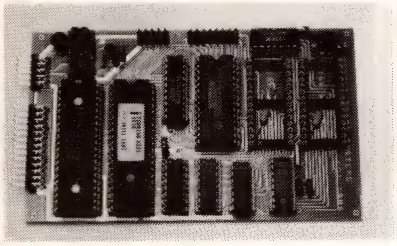
Introducing.....

the

SBS-52 Controller

from

Single Board Systems, Inc.



Standard Features

- Built In Basic
- 2 Real Time Clocks
- 32KX8 Static Ram
- 32 Programmable I/O Lines
- EIA Standard RS – 232 Port
- Built In Eprom Programming
- Standalone Developing
- Easily Expandable
- Large Line of Peripherals

Pricing:

1 – 4 unit cost $189.00

5 – 99 unit cost $164.00

Large Quantity Discount Available

Single Board Systems Inc.
P.O. Box 3788
Salem, Oregon
97302
(503) 581-6570

Stock to 3 Weeks

CIRCLE NO 46

contacts are sealed in a UL 94V-0 glass-filled polyester body. They feature standoffs that facilitate board cleaning, provide ventilation, and ensure proper wave-soldering. Funnel-shaped entry guides the IC leads and helps to minimize insertion problems. The sockets resist solder bridging and are packaged in standard tubes with color-coded stoppers that designate the number of contacts. $0.15 (1000) for a 16-position socket with phosphor-bronze contacts.

Precicontact Inc, Box 798, Langhorne, PA 19047. Phone (215) 757-1202.

Circle No 389

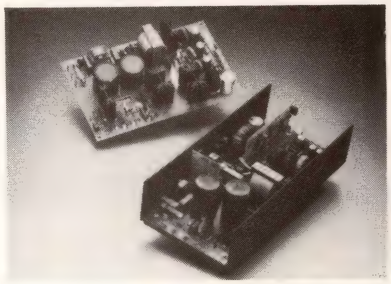
POLARIZED RELAY

- *1A/30V dc contact rating*
- *2-msec operating time*

The Model TQ relay has a 1A/30V contact rating, which meets the FCC standard for withstanding high-surge voltages. The relay features a 2 Form C contact arrangement, and it's available in three versions—single-side stable, 1-coil latching, and 2-coil latching. The pickup sensitivity specs at 140 mW for standard versions and 75 mW for sensitive single-side stable models. Operating and release times measure 2 and 1 msec, respectively. Nominal coil voltages range from 3 to 24V dc. The sealed construction of the relay allows automatic dip-washing, and standard presoldered terminals provide improved solderability in automatic soldering processes. Self-clinching terminals prevent the relay from lifting during the wave-soldering process. The relay's standard tube packaging, which is compatible with most vacuum-pickup heads, facilitates automatic-insertion operations. $4.50 (500). Delivery, four to six weeks ARO.

Aromat Corp, 250 Sheffield St, Mountainside, NJ 07092. Phone (201) 232-4260. TWX 710-997-9536.

Circle No 390



SWITCHING SUPPLY

- *Designed for hard-disk drives*
- *No fans or blowers required*

Model 4501 powers hard-disk drives. It utilizes a dual-MOSFET forward-converter circuit that switches at 100 kHz. Channels 1, 2, and 3 deliver 12V at 6A (12A pk), 5V at 6A, and −12V at 1A, respectively. The regulation specs at ±1% for channels 1 and 2, and ±3% for channel 3. The supply relies on convection cooling (no fans or blowers needed) and operates over 0 to 40°C with no derating. Its minimum efficiency equals 70%; ripple and noise specs at 1% or 100 mV, whichever is greater. Channels 1 and 2 feature overvoltage protection and also have electronic current-limiting circuitry for protection against short circuits. $53 (100).

Onan Corp, Power/Electronics Div, 4801 W 81st St, Suite 114, Minneapolis, MN 55437. Phone (612) 921-5600.

Circle No 391

SAW FILTERS

- *Suited for use in standard European TV sets*
- *Eliminate or retain the video carrier in the sound channel*

Providing 45 dB of attenuation at 38.9 MHz, the G3206 surface-acoustic-wave (SAW) filter eliminates the video carrier frequency from the sound channel of quasiparallel-sound TV sets. The filter has a typical insertion loss of 23 dB for the video channel and 26 dB for the sound channel. It's suited to use in Western European TV sets that em-

You don't have to call in the dogs to keep out the computer pirates.

Friendly, easy to use computer systems make things easier for your authorized users. Unfortunately, they also make it easier for computer pirates and others to pilfer your confidential data.

Problem: How to provide a secure computing environment. Solution: Call in Gould. We've developed an advanced operating system that eliminates unauthorized access without interfering with day-to-day operations. In addition, all who try to access information without the necessary authorization generate an audit trail that makes it easy to track them down.

The operating system? UTX/32S™ Based on our proven UTX/32® operating system, it's the only secure version of UNIX® that has been formally evaluated and rated at the C2 level as defined by the National Computer Security Center. And we're currently working on a B security level.

Naturally, your C2 operating system can be easily upgraded when needed.

Gould UTX/32S. It gives your computer environment security with real bite. Write or call for information.

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Computer Systems Division
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Fort Lauderdale, Florida 33313
1-800-GOULD-10, TLX 441491

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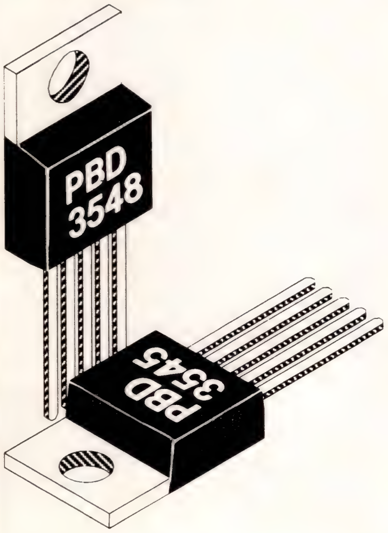
CIRCLE NO 185

RIFA's Sink/Source Drivers Are Smart — And Fast!



The **PBD 3548** is a 45V / 2A source driver that's really smart — it has internal protection diodes, over-current protection, and a temperature shut down function. An ERROR output indicates short circuit to GND, short circuit to V_{CC}, or open circuit load.

It's fast, too — full short-circuit protection is maintained even at switching frequencies up to 10 kHz, and over the full temperature range of -40°C to +85°C.

The **PBD 3545** sink driver incorporates the same protection and error detection circuitry as the **PBD 3548**.

Be smart — Use the **PBD 3545** or **PDB 3548** in any application that requires "fool proof" sink or source outputs.

For more information, write or call:

RIFA
quality for the future
Greenwich Office Park 3, P.O. Box 3110
Greenwich, CT 06836-3110
Tel: (203) 625-7300/7301
Telex: 221976 ERIAN UR
Telefax (203) 625-7357

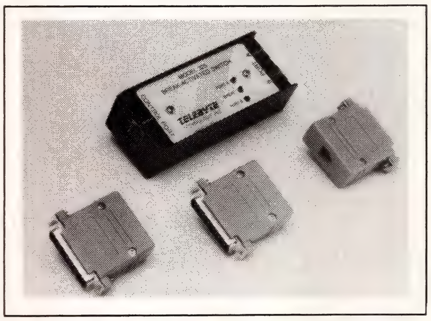
ERICSSON RIFA is a member of the Ericsson Group

CIRCLE NO 49

ploy the B/G TV standard. Another version, designated the G3250 and designed for use in TV sets with conventional quasiparallel-sound signaling systems, transmits the video carrier in its sound channel. The video- and sound-channel insertion losses for the G3250 are 17 and 20 dB, respectively. Both devices are housed in 10-pin DIPs. DM 4.

Siemens AG, Zentralstelle für Information, Postfach 103, 8000 Munich 1, West Germany. Phone (089) 2340. TLX 5210025.

Circle No 392



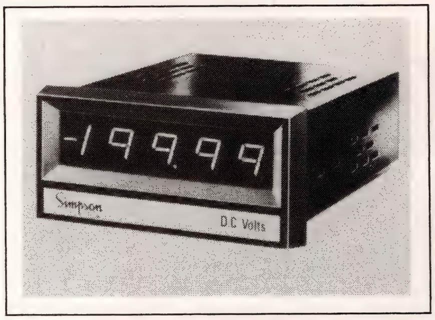
PORT SWITCH

- *Features three RS-232C ports*
- *Requires no power connections*

Using the Break key on the Model 325 break-activated switch, you can take data from a terminal or computer and direct it to one of two output ports. The switch module contains three RS-232C ports—a master I/O port, and two selectable I/O ports. All ports accommodate full-duplex, asynchronous data transmission at rates to 19.2k baud. The switch requires no ac or dc power connections. Its low-power logic derives operating power by sampling all of the available signals of the three RS-232C ports and stealing power from those able to supply it. The module features three LEDs, which indicate the selected port and whether a Break signal is being processed. $98.

Telebyte Technology Inc, 270 E Pulaski Rd, Greenlawn, NY 11740. Phone (800) 835-3298; in NY, (516) 423-3232.

Circle No 393



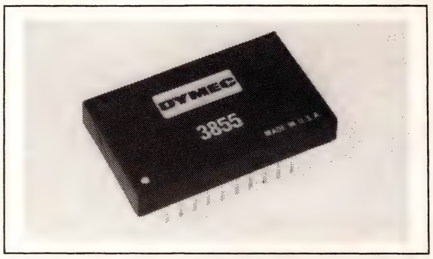
PANEL METERS

- *Feature high-intensity displays for easy reading*
- *Offer 0.02% accuracy and 10-μV resolution*

Series 2842 and 2843 digital panel meters (DPMs) feature high-intensity green or red LED displays for easy reading. They are available with stock ranges of 20 μV to 200V dc and 20 μA to 200 mA. They offer 0.02% accuracy and 10-μV resolution. Both units can fit into standard panel cutouts and include an I/O edge connector and a BCD output with a strobe line for interfacing with other measurement and control devices. The units are available with either 117V ac inputs (2842) or 5V dc (2843) inputs. Red display, $199; green display, $204.

Simpson Electric Co, 853 Dundee Ave, Elgin, IL 60120. Phone (312) 697-2260.

Circle No 394



CONVERTER MODULE

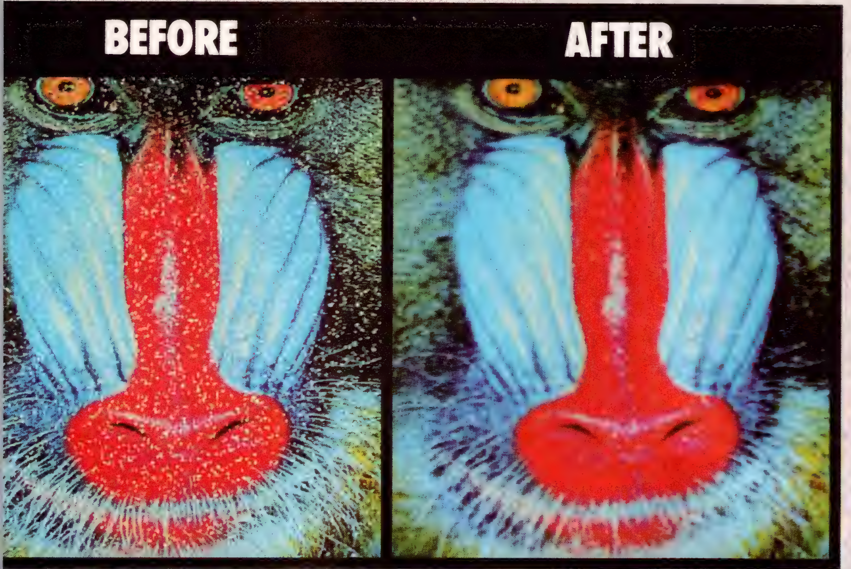
- *Features three functional blocks in a 24-pin package*
- *Input impedance of $10^{12}\Omega$*

Model 3855 integrates a high-input impedance buffer, a gain stage, and a precision V/F converter in a 24-pin plastic DIP. Each of the three functional blocks is accessible separately

REAL-TIME DIGITAL FILTERING NEVER LOOKED BETTER.

When it comes to high-speed digital filtering or correlation, Zoran's Digital Filter Processor (DFP) family makes it look better than ever.

Using system processors that deliver the high performance of building blocks. But with the high integration of a single device.



512 x 512 high-resolution image with randomly distributed noise.

Zoran's DFP performs *real-time* low-pass filtering to remove noise using a 7x7 convolution.

Each DFP is configured as a unique parallel-processing system capable of performing 320 million operations per second. At a blazing 20MHz throughput.

What's more, you can parallel multiple devices to reach throughput rates in excess of 120MHz.

And you'll do it in far less space, thanks to our highly integrated, proprietary architecture.

Which lets you design your system in a lot less time. At a lower cost. And with greater ease and flexibility than you ever thought possible.

The DFP is so flexible you can use a single device to easily implement a 32-tap decimate-by-four FIR filter.

The DFP makes all your applications look good. Take inspection, for example. You can execute complete 3 x 3 real-time imaging convolutions or correlations with a single DFP.

In high-speed satellite communications, digital radios, or radar, you can cascade multiple DFPs to achieve a higher sample rate and longer filter length, eliminating analog filters.

High-resolution video is easy with the 9-bit ZR33891, which delivers the longer word length and extended precision you need for studio broadcast applications.

You'll like the look of our tools and support. The shorter your development cycle, the better it looks. Which is why our VAX™ and PC-based tools provide you with everything you need for fast and easy implementation.

Including software for filter design and coefficient selection. And plug-in boards for real-time filter evaluation.

All of which explains why Zoran's DFP and Vector Signal Processor (VSP)™ product families provide the fastest, easiest solutions for computation-intensive applications.

Best of all, we're shipping products now. Instead of simply announcing them. Which means you don't have to wait to get the jump on your competition.

Take a look at our *free* databook. Call 1-800-556-1234, ext. 99 (outside CA), or 1-800-441-2345, ext. 99 (in CA). Or write Zoran Corporation, Dept. MC-1, 3450 Central Expressway, Santa Clara, CA 95051, 408/720-0444, ext. 3523. We'll make you look good in a hurry.

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THE LAST WORD IN DSP. ZORAN

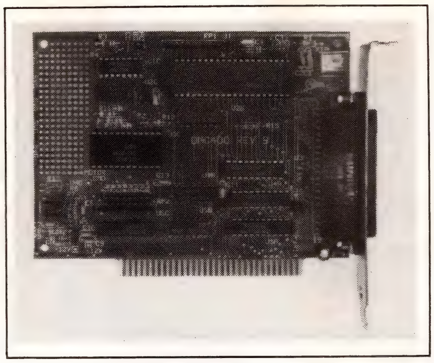
to maximize device flexibility. The input-inverting buffer has an input impedance of $10^{12}\Omega$. You program the gain with two RN55C resistors (you supply the resistors). The 5-MHz full-scale V/F converter features ±0.02% linearity for input signals from −100 μV to −10V. Differential-input configurations are available on a custom basis. $82 (100).

Dymec Inc, 8 Lowell Ave, Winchester, MA 01890. Phone (617) 729-7870. TWX 710-348-6596.

Circle No 395

MOTION CONTROLLER

- *Speeds range to 250,000 encoder counts/sec*
- *Can shut motor off when position error is excessive*



Units in the -10 Series of servo motor controllers feature a digital integrator, programmable torque and error limits, a position latch, and diagnostics. Speeds range from 4 to 250,000 encoder counts per second. You can change the acceleration, velocity, and direction of motion on the fly. The controllers can also operate in an incremental mode, in which each point on the desired position trajectory is entered every 0.5 msec. You can configure the units to shut the motor off whenever the position exceeds a preprogrammed limit. The diagnostics allow you to interrogate the controllers for status, position, and position-error data. The controller cards are available with VME (DMC-300-10), IBM PC (DMC-400-10), or RS-232C and STD (DMC-100-10) communications interfaces. $645 to $695.

Galil Motion Control Inc, 1054 Elwell Ct, Palo Alto, CA 94303. Phone (415) 964-6494. TLX 171409.

Circle No 396

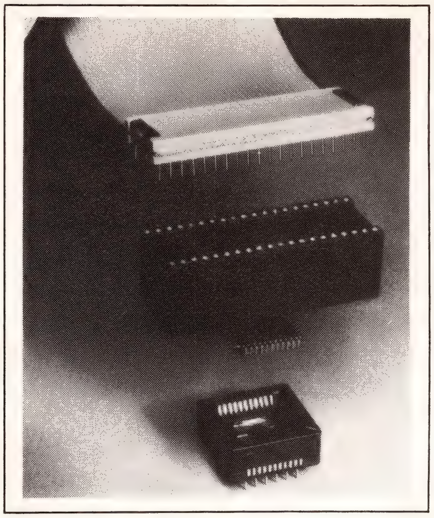
SOCKET ADAPTER

- *Interfaces in-circuit emulators to PLCC sockets*
- *Utilizes short interconnect leads*

The CA 1741 socket adapter allows you to interface standard in-circuit emulators to the 44-pin PLCC version of a μP. The family includes adapters for 8051, 8088, 6809, and Z80 μPs. The 40-pin DIP socket for the emulator probe is a standard 0.6-in.-wide, 0.1-in.-pitch connector, which is rigidly mounted to a

Nobody offers you a broader line of power semiconductors.

Nobody.



44-pin chip-carrier header plug. Interconnection leads between the two connectors are kept short to minimize interference and propagation delays. All the connector contacts are made of beryllium-copper. Approximately £212 (25).

Methode NSF Connectors Ltd, Halifax Rd, Ingrow Bridge, Keighley, West Yorkshire BD21 5HR, UK. Phone (0535) 603282. TLX 51270.

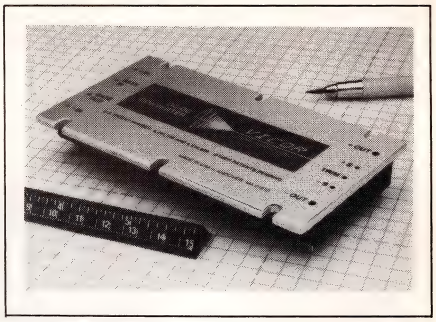
Circle No 397

Methode Electronics Inc, Backplane Div, 7444 Wilson Ave, Chicago, IL 60656. Phone (312) 867-9600. TWX 910-221-2468.

Circle No 398

DC/DC CONVERTERS

- *Minimum efficiency of 81%*
- *150W max output*



VI-200 Series dc/dc converters deliver as much as 150W. Based on a proprietary 1-MHz zero-current-switching topology, the units achieve a minimum efficiency of 81% for a 5V output (as high as 88% for higher output voltages). Input voltages range from 10 to 425V, and output voltages range from 2 to 48V in 50, 75, 100, and 150W power levels. The converters feature logic-disable, current-limiting, and remote-sensing functions, as well as overvoltage protection. Other specs include 0.1% line regulation, 0.2% load regulation, 2% p-p max output noise, and a 100-μsec transient response. The units also incorporate a 95°C thermal shutdown. $205. Delivery, six to eight weeks ARO.

Vicor Corp, 23 Frontage Rd, Andover, MA 01810. Phone (617) 470-2900. TWX 910-380-5144.

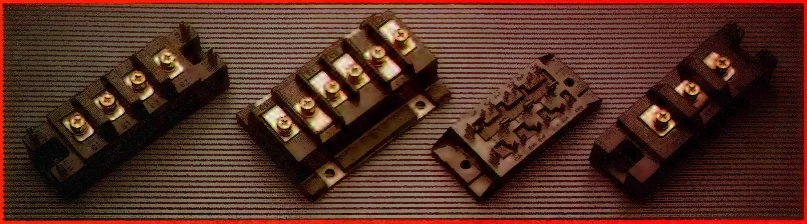
Circle No 399

Only POWEREX.

In 1986, Westinghouse, GE and Mitsubishi formed POWEREX to provide what no one else had provided before.

One-source convenience versus many-source chaos. Just-in-time delivery versus high inventory costs. Application assistance versus printed specifications. Innovation versus imitation. State of the art capabilities versus last generation obsolescence.

POWEREX versus the competition. Our advantages are obvious.



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Next generation FETMOD,™ cascade MOSBIP™ and cascode MOSBIP™ modules are available now from POWEREX. 15-100 amps, 450-1,000 volts for applications up to 100 KHz.

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For more information, phone (412) 925-7272.

POWEREX

Joint Venture Corporation of Westinghouse, General Electric, and Mitsubishi

CIRCLE NO 50

FILE CONVERSION

- *Lets you export files in any of nine popular formats*
- *Runs on IBM PC family*

The R900 Universal File Transfer software lets you transfer waveform data files that you've acquired, by means of the vendor's PC-based digital oscilloscopes or data-acquisition equipment, to nine popular processing programs: Asyst, Asystant, DADiSP, dBase III, ILS-PC1, ILS-PC2, Labtech Notebook, Lotus 1-2-3, and MathCAD. The menu-driven utility runs on the IBM PC and compatibles. It prompts you for all the information it needs in order to export the data in the correct format. The vendor also offers an option that allows the R900 utility to perform high-speed data acquisition in addition to its main data-export function. $199.

Rapid Systems Inc, 433 N 34th St, Seattle, WA 98103. Phone (206) 547-8311; TLX 265017.

Circle No 400

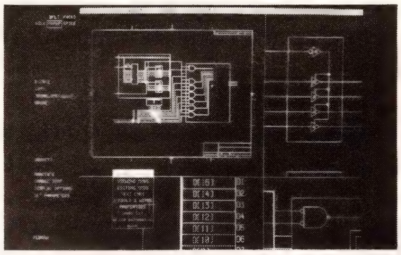
DEVELOPMENT KIT

- *Hardware/software kit for development of Multibus II I/O*
- *Includes debugger and diagnostics*

The MIB 186/110 is a development kit for Multibus II I/O circuitry in systems that require I/O facilities not provided on single-board computers. The hardware consists of an intelligent I/O development board equipped with an 80186 μP, as much as 256k bytes of EPROM, as many as 512k bytes of RAM, an 82258 DMA controller, an 8259 interrupt controller, and a serial communications port. Approximately one-third of the board is a prototyping area that has access to the local processor bus and allows you to build your customized interface circuitry. The board also has two iSBX expansion bus connectors that allow you to place additional circuitry on small mSBX multimodule expansion boards. The EPROM-resident software supplied with the board consists of the mSDM-186 monitor/debugger, an interconnect controller, and built-in, diagnostic self-test routines. This software lets you design and test both hardware and software without using an emulator; instead, you can use either a terminal connected to the serial port or an Intel development system (Series II or Series IV). $2000.

Micro Industries, 691 Greencrest Dr, Westerville, OH 43081. Phone (800) 446-6762; in OH, (800) 826-2237.

Circle No 401

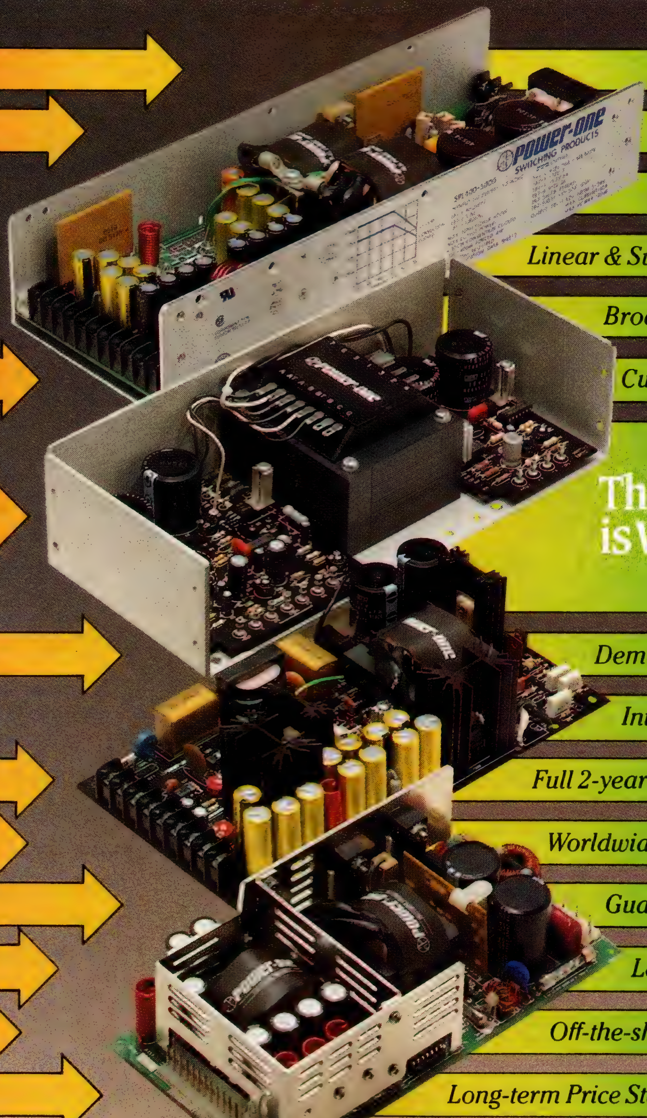


CAE TOOLS FOR PC

- *Symbol library has more than 2000 symbols*
- *Runs on IBM PC/AT*

The CapFast CAE tools, originally created for workstations, are now available in versions that run on the IBM PC/AT and compatibles. The basic package consists of a schematic editor, a symbol editor for creating and customizing electronic symbols, a symbol library containing more than 2000 symbols, and a plotter utility. The optional packages include an interactive simulator and netlisters. The netlisters convert CapFast schematic files to formats that can be used by popular pc-board-layout programs and simulators. You can also produce ASCII output files that you can edit with any text editor. To run these tools, you'll need an IBM PC/AT or compatible computer (or an 80386-based machine) equipped with 640k bytes of RAM, an IBM EGA or equivalent high-resolution graphics adapter,

Power-One Has Good News And Great News



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CIRCLE NO 186

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These ruggedly constructed, compact pots are available in sealed versions for PC mounted applications where board washing is required. They’re available with a variety of other options including multiple cups, switch sections, special bushings, special shafts, standoffs and more. Both the conductive plastic Model 148 and cermet Model 149 have a standard resistance range from 100Ω to 1 megohm; special resistance values on the Model 149 are available to 5 megohms.

For complete specifications on high quality panel control potentiometers—contact Spectrol today. **Spectrol Electronics,** 17070 E. Gale Avenue, City of Industry, CA 91745. Phone: (818) 964-6565. TWX: (910) 584-1314.

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HAMILTON STANDARD
CONTROLS

and a hard-disk drive. Basic package, $2600.

Phase Three Logic Inc, Box 985, Hillsboro, OR 97123. Phone (503) 640-2422.

Circle No 402

INTERACTIVE ANALYSIS

- *Provides time-series analysis*
- *Works with the vendor's RS/1 analysis system*

Dataprobe is an interactive time-series analysis and graphics package that runs on VAX/VMS machines and complements the vendor's RS/1 data-analysis software for engineering and scientific applications. The package allows you direct access to very large (gigabyte) data files, which you can manipulate interactively, without first having to load a database. The system has its own high-level, structured-command language that lets you create automated procedures for data analysis and for producing reports. You can also export selected raw data or analysis results to external programs written in C or Fortran. From $30,000 (including one year of maintenance).

BBN Software Products Corp, 10 Fawcett St, Cambridge, MA 02238. Phone (617) 864-1780.

Circle No 403

TOOL KITS

- *CMT provides configuration management for workstations*
- *DST tracks changes in software documentation*

The Configuration Management Toolkit (CMT) and the Documentation Support Toolkit (DST) both run on the Sun-3 family of workstations under the Sun OS, which is a hybrid version of Unix System V and BSD 4.2. The CMT provides you with a systematic method of controlling all changes to software, hardware, and documentation during the development of a software project. This tool

Domenic Melcher, Director of R+D

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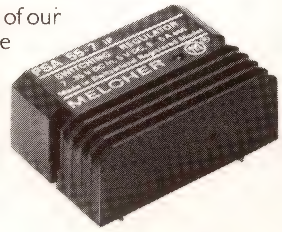
CIRCLE NO 51



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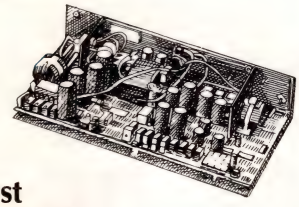
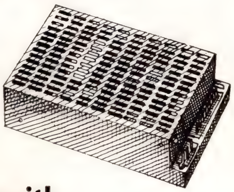
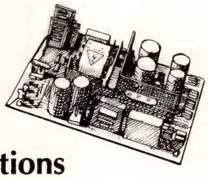


- Most standard units available from stock



- Most models with UL, CSA, VDE and IEC certification



- Modifications welcomed

For complete technical specifications or information on price and delivery, please call our Applications or Sales Departments.

POWERLINE

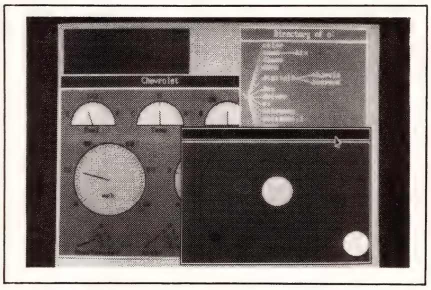
10 Cochituate Street
Natick, MA 01760
TEL: 617-655-7987
TWX: 5101003630
FAX: 617-655-7984

CIRCLE NO 52

kit provides complete release-management data for each successive configuration of the project as development progresses. The DST not only lets you create documentation on line, but also provides a comprehensive set of templates and scripts (including those of DoD-STD-2167) that can generate documentation from engineering data. The DST closely tracks all the changes made during the development of a project so that documentation is finished at the time the new software is ready for delivery. To run these tool kits, you need 2M bytes of disk space for program storage and 2M bytes of RAM for efficient operation. Prices vary according to workstation configuration; they start at $12,000 for the CMT and $10,000 for the DST.

Expertware Inc, 3235 Kifer Rd, Santa Clara, CA 95051. Phone (408) 746-0706.

Circle No 404



SMALLTALK KITS

- *Integrate EGA color capabilities in Smalltalk*
- *Provide simulation kernels*

Two extension kits enhance the capabilities of Smalltalk/V, the vendor's IBM PC-based implementation of the Smalltalk object-oriented language. The color-extension kit lets you use all the capabilities of the Enhanced Graphics Adapter (EGA) board and makes it easier for you to create user interfaces that communicate information simply and graphically. With the aid of this kit, the Smalltalk bit editor and paint program can create multicolored icons. The Goodies kit provides priority-scheduling and multitasking facilities, along with a forward-chaining inference mechanism that complements the backward-chaining mechanism already included in the language. This kit also provides a DOS-call feature that can generate any PC-DOS interrupt from within a Smalltalk/V program; a Zoom feature that lets you expand any text window to the full size of the screen; a Music feature that lets you create, store, and replay simple musical compositions; and an object-loader/unloader feature that lets you transfer complex Smalltalk objects between memory and disk or between memory and a telecommunications channel. $49 each.

Digitalk Inc, 5200 W Century Blvd, Los Angeles, CA 90045. Phone (213) 645-1082.

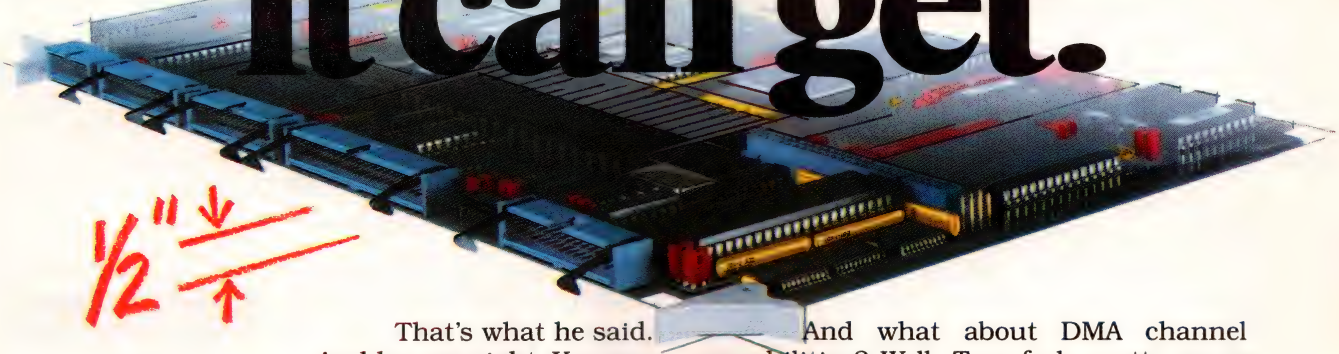
Circle No 405

ADA TOOL

- *Generates documentation from source code*
- *Lets you extract constructs for further processing*

The Byron PDL program-development language and documentation generator is an extension of Ada. It allows you to embed PDL constructs in Ada comments; the compiler ignores these constructs, but the Byron documentation generator uses them to create documentation in a format that conforms to any specification, even a MIL-STD specification. The documentation generator allows you to set up templates that can produce a variety of different documents from the same Ada source code. The final document is ready to print, and it includes a cover page, table of contents, and index. The Program Library Access Package (PLAP) and a text formatter come with the Byron package. The PLAP provides a set of Ada abstractions that you can call from an external program to extract information from the library. You can then process this information to generate types of output other than

"It's expanded as small as it can get."



That's what he said. And he was right. You see, our SBC design engineer, Tom Murphy, was convinced he could come up with a better board than Intel's 286/12. For months he'd been working with our new Multibus* 80286 SBC, making sure it was compatible with Intel, but adding refinements, improvements and putting more capabilities onboard.

But more wasn't enough for Tom, he wanted less, too.

"There's gotta be a way to pack all these capabilities on to a board that only takes up one slot."

And that's just what he did. Our 80286 uses the latest in surface-mount and RAM packaging, putting it all onboard . . . not on top. That skinnied it up right there. But Tom wasn't satisfied. He put four serial I/O ports onboard ("Intel has two, so we'll double it," he said). That means no more expansion modules, less bulk and less cost.

And what about DMA channel capabilities? Well, Tom feels pretty smug about **that** enhancement. Starting with full duplex DMA for two serial ports, he added multiplexed channels . . . eight to be exact. (Don't even bother to look for any on their board). So all four serial ports are serviced with three DMA channels left open. Open for whatever **your** creativity demands.

Tom came up with other great ideas, all of which are in our brochure, but think about what you can do with just what we've mentioned.

Then think about picking up the phone. Call Mike Heins, SBC Product Manager at 1-800-482-0315. It's toll free. (In Illinois, call 217-359-8010). Ask him to send you a brochure, give you specs and prices or, if you like, he'll even connect you directly to Tom.

Or write us, Central Data, 1602 Newton Drive, Champaign, IL 61821-1098.

Central Data

**Multibus is a trademark of Intel Corporation.*

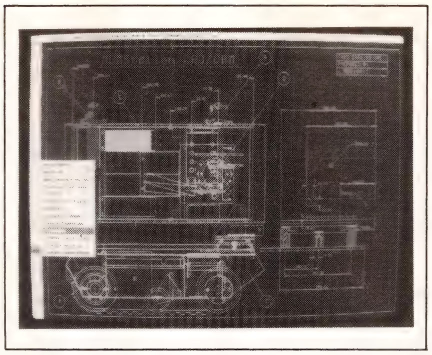
those provided by the templates. The Byron package runs on VAX/VMS systems. From $10,000.

Intermetrics Inc, 733 Concord Ave, Cambridge, MA 02138. Phone (617) 661-1840; TWX 710-320-7523.

Circle No 406

CAD FOR MAC

- *Has English or metric dimensioning*
- *Provides draftsman's tools such as fillets and splines*



The MGMS Professional CAD for Mac is a software package for mechanical and electrical engineers, draftsmen, and architects. The program runs on a Macintosh equipped with 512k bytes of RAM and offers Cartesian, absolute, incremental, and polar measuring systems. You can use either English or metric dimensions; their 4-decimal-place accuracy is based on calculations to 15 decimal places. You can create lines, circles, and arcs by a variety of methods. A geometric module calculates the arc, perimeter, center of gravity, and moment of inertia for objects of any shape. A library feature stores symbols and drawings that can be called up by name or shape, retrieved at any angle, and oriented to any angle. Each library can hold as many as 50 symbols, subassemblies, or complete parts, and the number of libraries is limited only by the available disk space. You can enter text in paragraphs that you can move, box, or circle. Several fonts are provided, and you can set any point size. The program stores images in Pict format and can transfer drawings to and from MacDraw, MacDraft, or MacWrite. An optional module allows you to transfer drawings in the IGES (International Graphic Exchange Standard) format to or from other computers. $799.

Micro CAD/CAM Inc, 3230 Overland Ave #105, Los Angeles, CA 90034. Phone (213) 376-6860.

Circle No 407

COMPILERS

- *Fortran 77, Pascal, and C compilers run on Macintosh II*
- *Provide IEEE-standard format for floating-point operations*

These high-performance, optimizing compilers for Fortran 77, Pascal, and C now run on Apple's Macintosh

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CIRCLE NO 53

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CIRCLE NO 54

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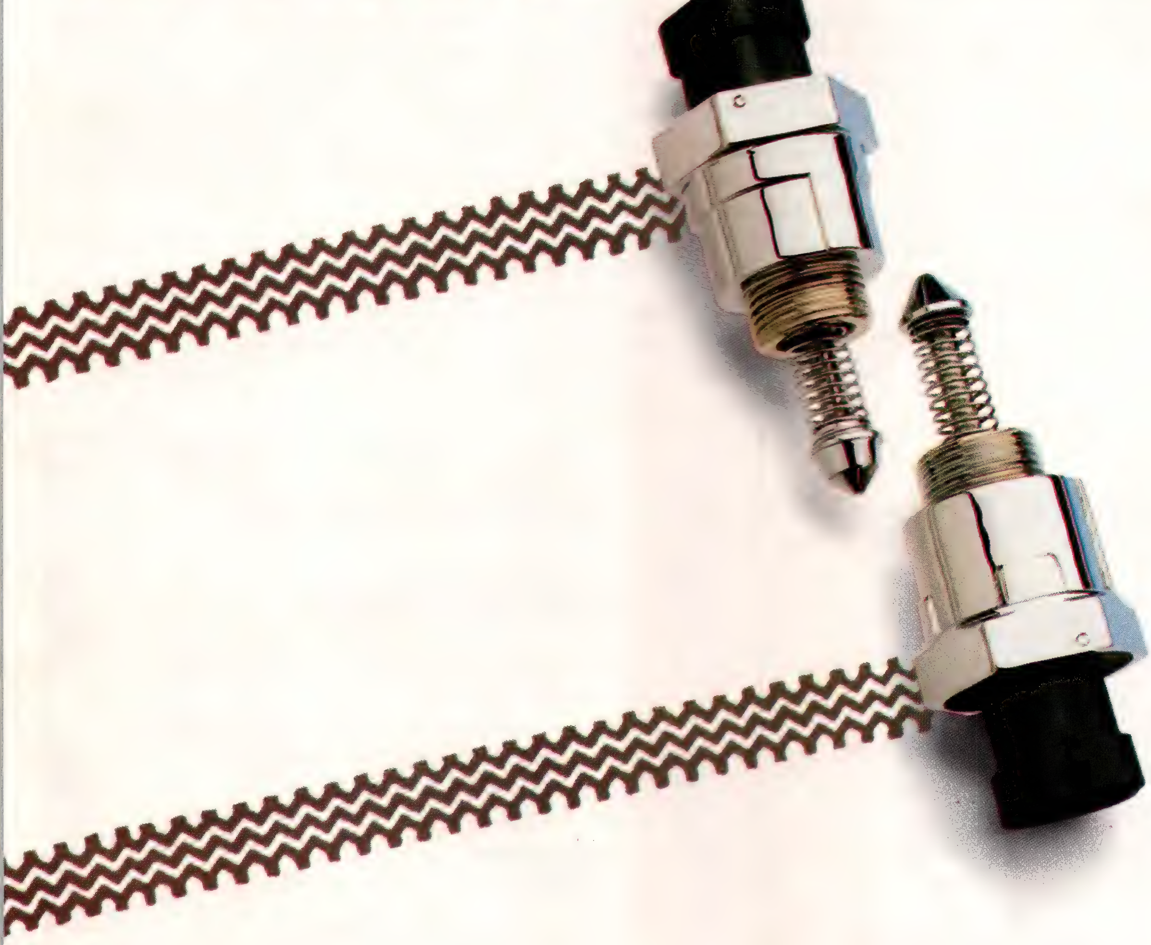

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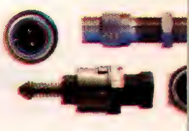
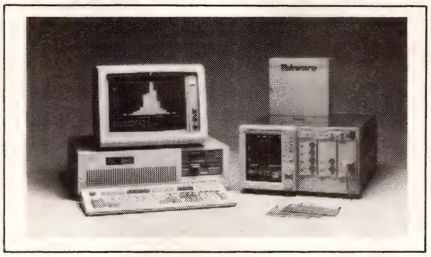


II computers under the A/UX operating system. A/UX is the vendor's implementation of Unix: It combines the features of AT&T's System V.2 and System V.3 with those of BSD 4.2 to provide maximum functionality and program portability. The compilers have a 1-pass design, which maximizes compilation speed. They generate 68000 or 68020 assembly-language output in UniPlus+ or Motorola format and provide calling sequences that are compatible with the vendor's other compilers. According to the vendor, benchmark tests conducted at the University of California at Berkeley show that these compilers generate code that is 30% smaller and two to four times faster than the code produced by other compilers for these languages. $700 each.

UniSoft Corp, 739 Allston Way, Berkeley, CA 94710. Phone (415) 644-1230.

Circle No 408



OSCILLOSCOPE LINK

- *Links digitizing scopes to IBM PC-based controllers*
- *Lets you automate measurement procedures*

The 11300 and 11400 Series IBM PC Utility Software packages allow you to use IBM PCs as controllers for the vendor's 11301, 11302, 11401, and 11402 digitizing oscilloscopes. You can set up routine tasks such as the acquisition, storage, and graphing of waveform data, and the transmission of test-setup data to the instruments. The packages include source code that is compatible with the IBM Basic Compiler version 2.0 or Microsoft's QuickBasic version 2.0. The menu-driven utilities let you archive oscilloscope front-panel settings for future use, acquire digitized waveforms from the oscilloscopes, collect measurements at preset intervals and log them in disk files, or dump collected data to standard IBM printer ports for hard copy. To run these software packages, you'll need an IBM PC, PC/XT, PC/AT, or compatible machine equipped with 640k bytes of RAM, two or more disk drives (of which one must be a double-sided floppy-disk drive), an IBM Color Graphics Adapter or equivalent, and either a standard RS-232C serial port (COM1) or a National Instruments GPIB interface card. $450 each.

Tektronix, Marketing Communications Dept, Box 1700, Beaverton, OR 97077. Phone (800) 547-1512; in OR, (800) 542-1877.

Circle No 409

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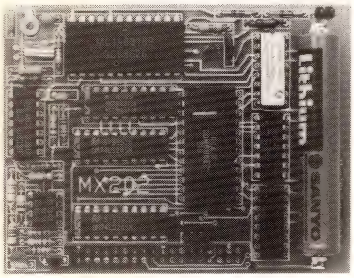
New!



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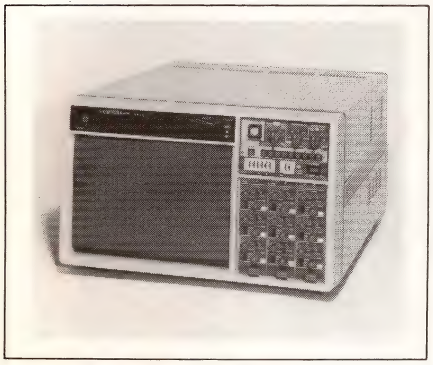


OSCILLOGRAPH

- *Fiber-optic chart recorder has 10-kHz bandwidth*
- *Records as many as nine channels at once*

The Lumigraph 5F15 oscillographic recorder uses a fiber-optic CRT instead of a galvanometer. The 9-channel unit has a 10-kHz bandwidth for 50-mm p-p (reduced-amplitude) signals. Its maximum signal amplitude is 200 mm p-p. The instrument's linearity measures ±0.5% for full-scale waveforms. The chart speeds range from 400 to 0.1 cm/sec. Besides printing waveforms, the recorder prints grid lines and annotations. IEEE-488 control is optional. $15,500.

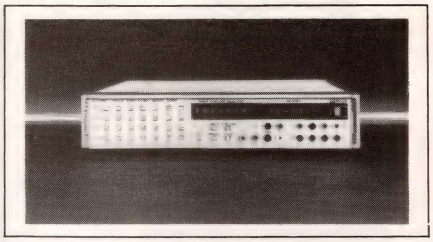
Soltec Corp, Sol Vista Park, San Fernando, CA 91340. Phone (800) 423-2344; in CA, (818) 767-0044.

Circle No 421

SYNCHRO SIMULATOR

- *Replaces mechanical components*
- *Has 3-arc-sec accuracy*

The L200 synchro simulator replaces known-good mechanical units in synchro/resolver test setups. The instrument exhibits 3-arc-sec accuracy and 0.36-arc-sec resolution. The unit incorporates a power oscillator, a digital modulator, a phase shifter, and a dc power supply. The instrument is IEEE-488 programmable. Its outputs include sine, square, and triangle waveforms. You can simulate a synchro/resolver that is rotating at a constant rate. From $20,000. Delivery, 12 to 16 weeks ARO.



Natel Engineering Co Inc, 4550 Runway St, Simi Valley, CA 93063. Phone (805) 581-3950. TWX 910-494-1959.

Circle No 422

Need help turning your "designs" into reality...?

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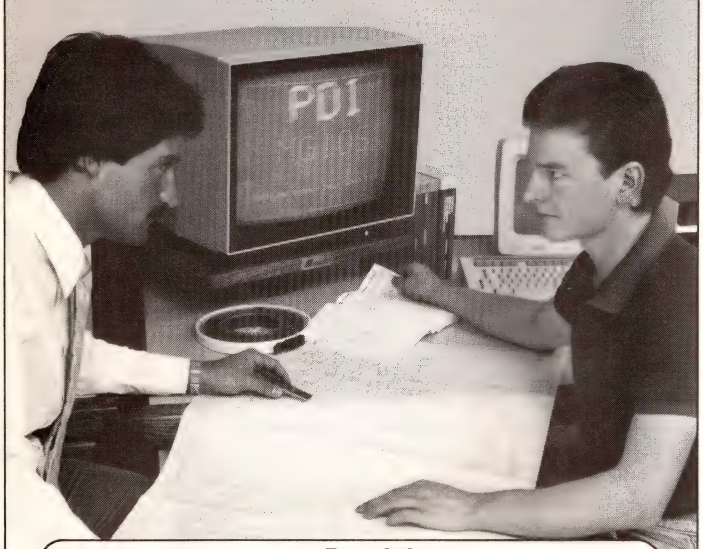
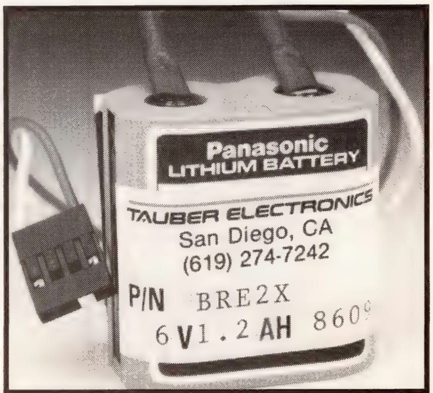


PDI

Precision Diversified Industries, Inc.

15285 Minnetonka Boulevard
Minnetonka, Minnesota 55345
(612) 935-8825

CIRCLE NO 57



Introducing an Easy-To-Get, Money-Saving Clock Battery Replacement.

Tauber Electronics' new lithium real-time clock/memory battery assembly is the cure for your clock battery failure problems. This U.L. listed battery replacement unit features no load voltages, 6.4 or 7.2 volts, capacities of 1.2 to 2.0 A.H., and a velcro fastener system. You have your choice of resistor or diode. And you'll save more than 25% over replacement batteries from the leading replacement battery manufacturer. Best of all, you get immediate delivery. So call now to learn more.

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FAX 619/274-2220; LA 213/416-9000
OC 714/667-0177; N. CA 408/737-9408

CIRCLE NO 58

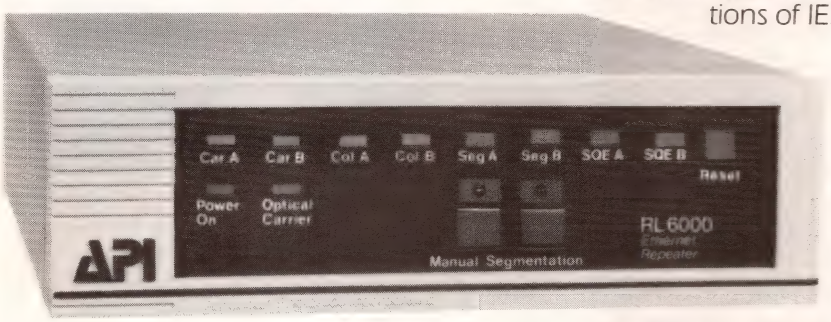
THE RL6000 ETHERNET REPEATERS

NO ONE MAKES A MORE COMPATIBLE, A MORE CAPABLE, A MORE TROUBLE-FREE ETHERNET REPEATER.

NO ONE.

Let's start with RL6000 compatibility.

Both the Local (RL6000 L) and the Remote (RL6000 R) Repeaters meet and exceed all specifications of IEEE802.3 and Ethernet V.1 and V.2 networks.



Connections can be made with either coax cable (Local) for segments greater than 50 meters apart or with fiber (Remote) for segments up to 1km.

With fiber, you're free to connect with any standard core size.

No one else offers these features. This is unique with API.

Next, the RL6000's capability factors.

Both the Local and the Remote units feature front-end diagnostic lights to indicate the presence of Ethernet packets or collisions. If excessive collisions are detected, the repeater will automatically segment the Ethernet section causing the problem. There are also manual segmentation switches for rapid system de-bugging.

Again, no one else offers this feature. This is unique with API.

API Repeaters can regenerate and retime even severely distorted data packets and restore them to original quality.

As with all of API's fiber-optic transmission products, their modular features will allow you to build, extend or reconfigure your network as your needs change—without sacrificing your investment.

CALL 800-626-5745.
ASK ABOUT OUR RL6000 SERIES ETHERNET REPEATERS AND OUR OTHER OFF- THE-SHELF T1 AND ETHERNET PRODUCTS.

"And what about trouble-free? Simple.
We'll warranty everything for two years. Who else is offering that much? No one."

James A. Walyus, Chairman and CEO

API

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THAN YOU'VE EVER GONE BEFORE

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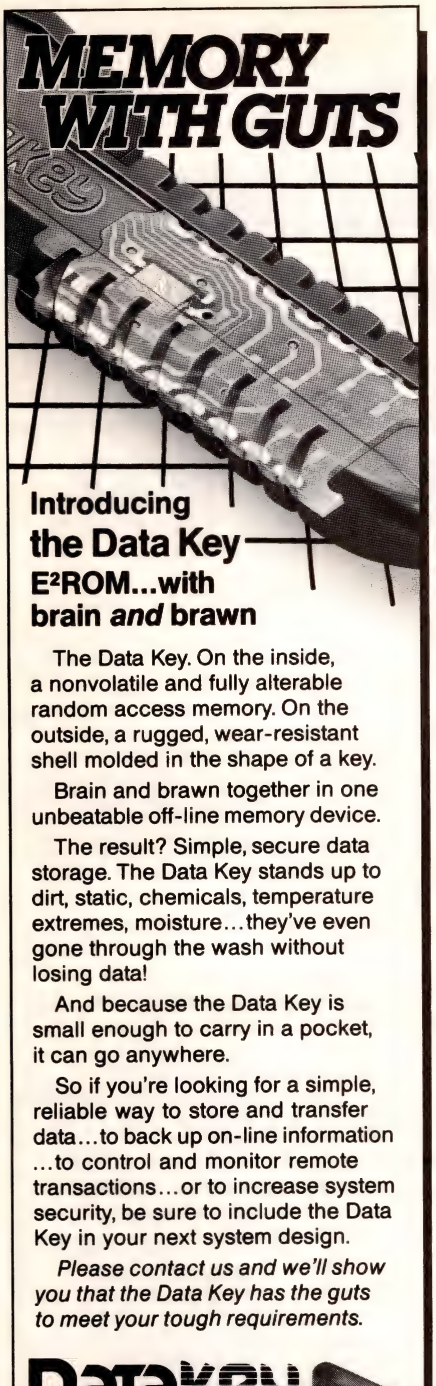

Introducing the Data Key

E²ROM...with brain *and* brawn

The Data Key. On the inside, a nonvolatile and fully alterable random access memory. On the outside, a rugged, wear-resistant shell molded in the shape of a key.

Brain and brawn together in one unbeatable off-line memory device.

The result? Simple, secure data storage. The Data Key stands up to dirt, static, chemicals, temperature extremes, moisture...they've even gone through the wash without losing data!

And because the Data Key is small enough to carry in a pocket, it can go anywhere.

So if you're looking for a simple, reliable way to store and transfer data...to back up on-line information ...to control and monitor remote transactions...or to increase system security, be sure to include the Data Key in your next system design.

Please contact us and we'll show you that the Data Key has the guts to meet your tough requirements.

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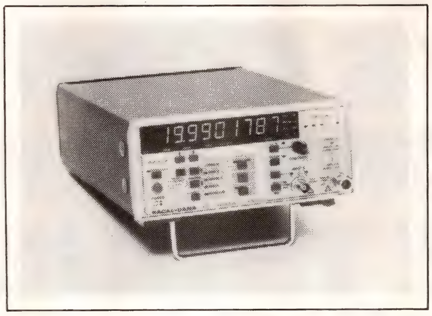


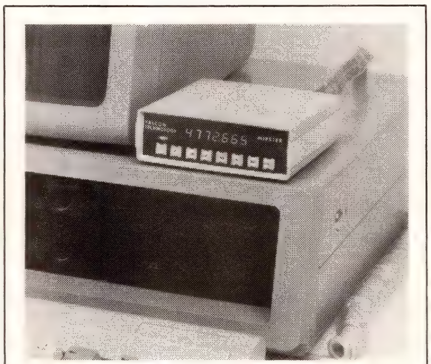
FREQUENCY COUNTER

- *Has 2.6-GHz bandwidth*
- *Can take 6-digit reading in 2 msec*

The Model 1999 frequency counter covers the 10-Hz to 2.6-GHz frequency range. At 2.6 GHz, its sensitivity is 10 mV. The instrument has 9-digit resolution and offers timebases of varying accuracy. It can take a 6-digit reading in 2 msec min. Besides taking single-channel frequency and period measurements, you can measure the ratio and difference of two frequencies. IEEE-488 programming is optional. $2400. Delivery, six weeks ARO.

Racal-Dana Instruments Inc, Box C-19541, Irvine, CA 92713. Phone (714) 859-8999. TWX 910-595-1136. TLX 678341.

Circle No 423



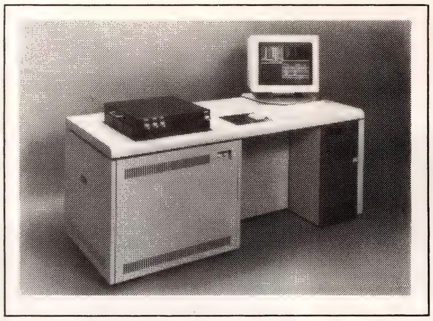
μP SPEED MONITOR

- *Counts instructions per second for 8086/88 systems*
- *Measures real-time software efficiency*

The Mipster is a modular measuring instrument for CPU-based systems. It plugs into the μP socket of an 8086/88-based product and measures instructions per second, number of memory accesses, number of I/O-port accesses, number of times the μP flushes its queue, and CPU clock frequency. You can operate the instrument continuously or trigger it on and off with an I/O instruction that you insert in your program. $495.

Falcon Technology Inc, 664 Hawthorne St, Glendale, CA 91204. Phone (818) 244-6460.

Circle No 424



DIAGNOSTIC SYSTEM

- *Diagnostic aid uses net lists to scan ASICs*
- *Scanning electron microscope shows chips in action*

Using scanning-electron-microscope technology, the IDS 5000 allows you to observe the response of ASICs (application-specific integrated circuits) to test signals. The instrument's controller uses net lists and other information from CAD/CAE software to show the portion of the circuit diagram that corresponds to the portion of the IC under observation. The instrument can display the results of its nonintrusive, electron-beam probing in real time. The controller can also display test-vector and ASIC-response waveforms simultaneously with net lists, schematics, and ASIC images. $495,000. Delivery, 90 days ARO.

Sentry/Schlumberger VHSIC Test Systems, Advanced Products Group, 1601 Technology Dr, San Jose, CA 95110. Phone (408) 437-5000. TWX 910-338-0558.

Circle No 425

VF Technology... The Bright Decision

Futaba, a world leading manufacturer of vacuum fluorescent displays, offers a wide assortment of *display tubes* in many sizes and formats. Also, Futaba offers *display modules* with all the electronics required to refresh the display and easily interface with the host system.

GRAPHIC DISPLAY

Both front glass phosphor, which provides maximum viewing angle and uniform surface appearance, and conventional back glass phosphor, with optimum brightness and software dimming capabilities, are available. All Futaba graphics modules offer complete drive electronics, bit mapped control with a DC/DC converter. All active components are surface mounted onto a single board.

DOT MATRIX MODULES

Utilizing Futaba's dot matrix displays, a completely intelligent line of "dot modules" is available. Each includes all drive, power supply and microprocessor components surface mounted onto a single board. Surface mounted technology results in higher reliability and allows for a smaller overall package and lower cost. All dot modules require only a 5V DC power source and can accept parallel or 8 possible serial baud rates.

GRAPHIC DISPLAYS/MODULES

Futaba Display	Futaba Module	Pixels (Row X Char.)	Brightness (FT-L)	Module Dimensions (in.)
GP1005B	GP1005B03B	128X64	400	7.28X3.35X1.77
GP1006B	GP1006B04B	256X64	200	9.84X3.35X1.77
GP1009B	GP1009B03B	240X64	200	6.2X2.76X1.57
GP1010B	GP1010B01B	176X16	200	7.32X2.16X1.70
GP1002C	GP1002C02B	320X240	100*	7.10X6.30X1.60

***Different Versions Available**

DOT MATRIX DISPLAYS/MODULES

Futaba Display	Futaba Module	Char. X Row	Dot Format	Char. Ht. (in.)	Module Dimensions (in.)
20SD01Z	M20SD01CA	20X1	5X7	0.200	6.3X1.97X.75
20SD42Z	M20SD42CA	20X1	5X12	0.344	7.1X2.16X.88
40SD02Z	M40SD02CA	40X1	5X7	0.200	9.45X2.16X.88
40SD42Z	M40SD42CA	40X1	5X12	0.344	9.45X2.16X.88
202SD03Z	M202SD03CA	20X2	5X7	0.200	6.7X2.56X.90
402SD04Z	M402SD04CA	40X2	5X7	0.200	10.43X2.56X.90
MANY OTHER DISPLAYS	**NEW MODULES AVAILABLE SOON**				

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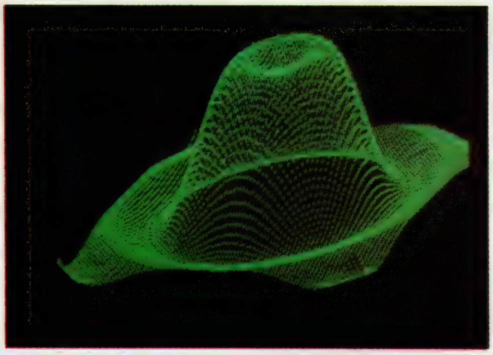
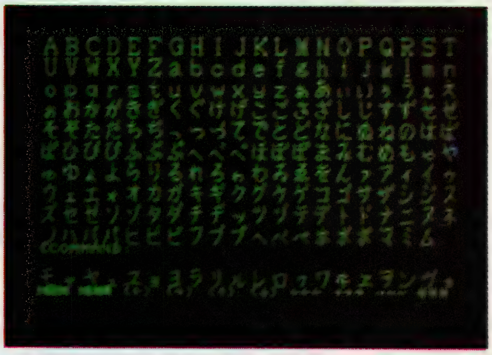
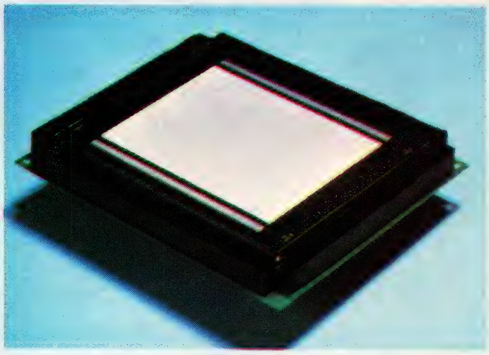
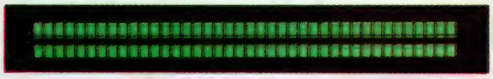
Corporation of America
Electronic Components Division
711 E. State Parkway, Schaumburg, IL 60195 • Telephone: (312) 884-1444 Telex: 206-833

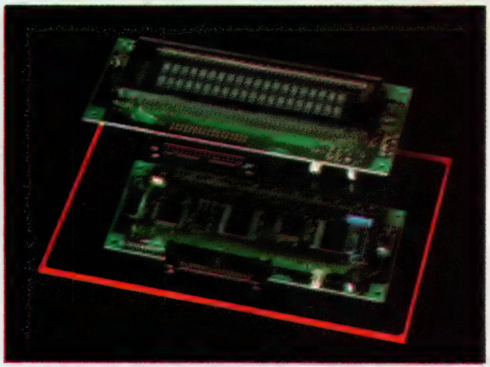






Compact, flat panel graphic displays and modules present clean, sharp images, whether for text or full graphics application.



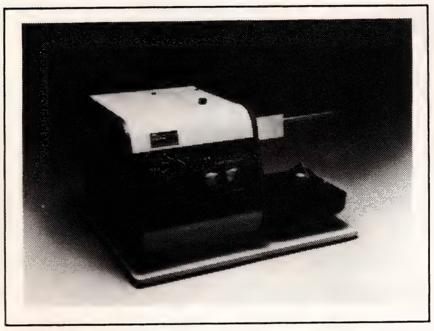


Pattern flexibility and pleasing appearance are offered by Futaba in dot displays and modules.

Futaba also offers a complete catalog of alphanumeric, segmented displays.

Futaba supports its products with design engineering and system integration assistance. Call or write today.

CIRCLE NO 192



LEAD TESTER

- *Conforms to MIL-STD-883C conditions B.1 and B.2*
- *Bends a component's leads until they break*

The Model 410 lead fatigue tester applies bending stresses to a component's leads in accordance with MIL-STD-883C conditions B.1 and B.2. You can adjust the cycle-time tester from 2 to 5 sec in 1-sec increments. You can also set the total angle of the bend from 15 to 90° in 15° increments. When a component's lead fails, the tester automatically shuts off and displays the number of completed test cycles. The unit comes with holders for lead frames. An optional holder accommodates other device packages. $2000.

Anza Tech Inc, 2231 Via Maderos, Los Altos, CA 94022. Phone (415) 967-0111.

Circle No 426

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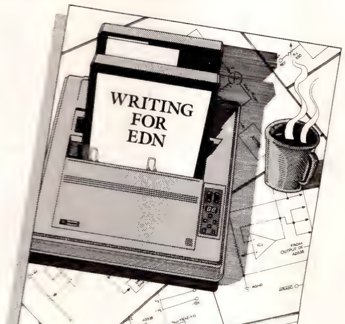

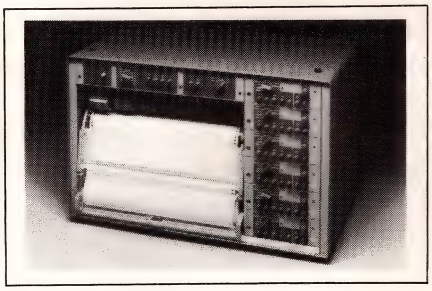

RECORDER

- *Available in 2-, 4-, or 6-channel versions*
- *Input modules include true-rms measurement capabilities*

The C1013, C1014, and C1015 recorders are available with two, four, or six input channels, respectively. The range of available plug-in input modules for the recorders includes modules for dc-voltage and true-rms-ac measurement. The recorders' response time is 0.3 sec; their recording speed is 100 cm/sec. You can choose from 12 paper speeds ranging from 3 to 120 cm/min or 3 to 120 cm/hour. The recorder accepts either roll or fan-fold paper and uses fiber-tipped pens. The recording area is 250 mm wide. You can pivot the chart carriage as far as 45°. The recorders provide for event marking and offset compensation. The units are available in benchtop or rack-mountable versions. You specify the C1013's input-channel configuration. The C1013 mainframe costs £899, and its input modules range

One OMNI can program *and test* everything from micro-power PLDs to fully populated PC boards.

The Ultimate Programmer. OAE has drawn upon 12 years of research and manufacturing experience to develop the ultimate software configured programmer.

The OMNI combines ***high-power, high-resolution,*** software configured pin drivers with a huge database of PROMs, EPROMs, EEPROMs, EAROMs, PLDs, microprocessors and ASICs (Application Specific ICs) to eliminate costly and outdated configuration modules and programming adapters.

The OMNI's patented pin drivers let you program and test more devices than any other system. The OMNI provides ***unlimited support*** from bipolar diode arrays to micro-power CMOS PLDs like the HPL-16LC8. And now you can program hybrid modules and complete PC boards with the OMNI 64.

Want to enter your own test and programming parameters? Just use the optional parametric editor to screen every device programmed to your own specifications.

- 100% Software Configured.
- Fast, high voltage, high current pin drivers can supply +-1.5A continuous to +-10A peak at each pin.
- Over 4,000 steps of voltage and current resolution and *sub*-nanosecond timing resolution.
- 100% laser trimmed for high speed and accuracy. No calibration is ever required.
- Plug compatible with over 350 different computers.
- Add over 20,000 new devices by modem, diskette, or RLB module.
- The OMNI 64 supports ALL package types, including SOs, LCCs, PLCCs, PGAs, DIPs, SIPs, etc.
- ***Free library updates for 2 years.***
- Small, portable and easy to use.

Prices start at just $3250.

OAE

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(800) 828-0080 or
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CIRCLE NO 193

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Discover the full line of solutions Carroll Touch offers. From infrared to overlay touch products. Select from a wide range of standard add-on units in a variety of sizes. Or from a line of fully integrated computer displays equipped with touch. Or specify your own unique requirements.

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CIRCLE NO 194

from £97 to £219. The C1014 and C1015 mainframes cost £1965 and £2772, respectively; their plug-in modules range from £79 to £195.

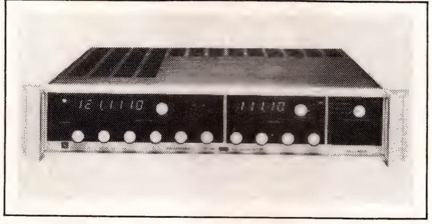
Advance Bryans Instruments Ltd, 14-16 Wates Way, Mitcham, Surrey CR4 4HR, UK. Phone 01-640 5624. TLX 946097.

Circle No 427

AC CALIBRATOR

- *Covers 30 Hz to 120 kHz*
- *Voltage output ranges from 1 mV to 120V*

The Model 4503 ac-voltage calibrator covers the frequency range of 30 Hz to 120 kHz with 0.001% frequency accuracy. Its outputs range from 1 mV ac to 120V ac with a 1-ppm resolution. Its amplitude accuracy is 0.04%. An optional amplifier extends the calibrator's coverage to 1000V ac. The output distortion is less than 0.1%. The rack-mount unit is programmable over the IEEE-488 bus. $3995. Delivery, 60 days ARO.



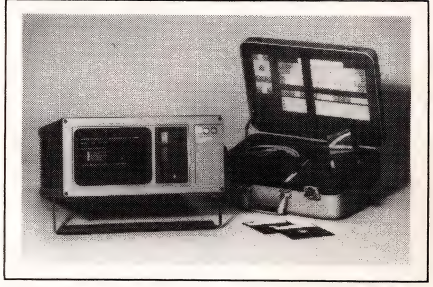
Electronic Development Corp, 11 Hamlin St, Boston, MA 02127. Phone (617) 268-9696.

Circle No 428

DEVELOPMENT SYSTEM

- *Supports most 8- and 16-bit μPs*
- *Incorporates a 20M-byte Winchester disk*

The KPDS can act as a stand-alone portable software-development system or as a universal emulator workstation interfaced to a minicomputer. The unit has a 616k-byte (formatted) floppy-disk drive and an integral 17.5M-byte (formatted) Winchester disk that stores program-development utilities. You can increase its program-assembly speed by adding an optional 1M-byte RAM disk. The emulator supports most 8- and 16-bit μPs at their full system-clock frequencies; to adapt to each μP, it requires only a plug-in personality card and a new probe. You can expand the emulation memory to 128k bytes, and you can map memory between the emulator and the target system in 256-byte blocks. Its memory-management unit allows you to simulate



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INSIDE

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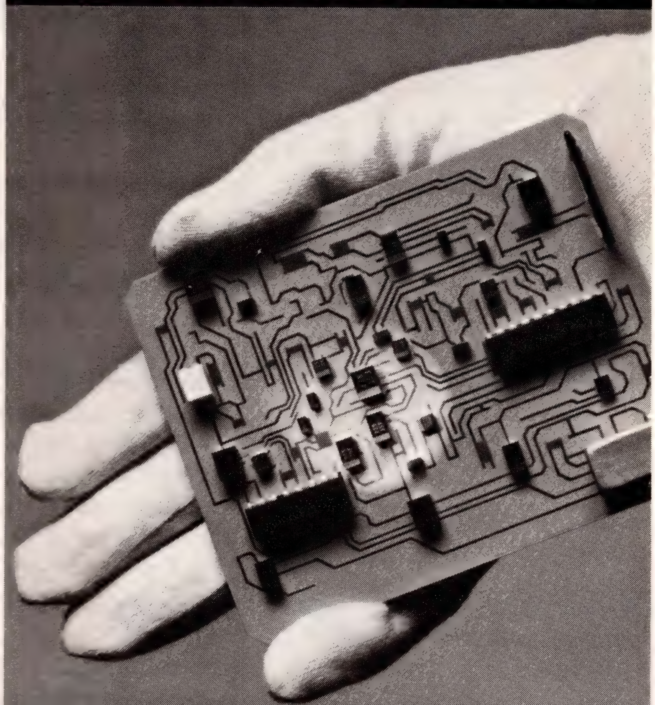
Power MOSFET Makers Boost Electrical Specs

HOT NEWS OF PRODUCTS, TECHNOLOGY, AND CAREERS

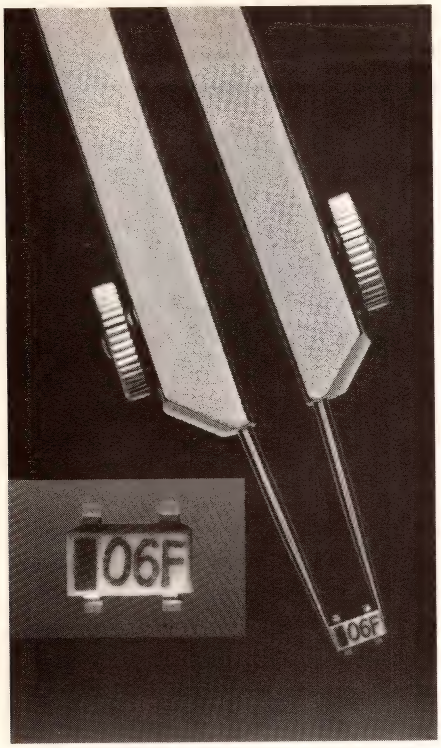
CIRCLE NO 61

TANTALUM CHIP CAPACITORS FOR SURFACE-MOUNT DEVICES



MATSUO ELECTRONICS
2134 Main Street, Suite 200
Huntington Beach
California 92648
(714) 969-2491
FAX (714) 960-6492
TWX (910) 596-1828

CIRCLE NO 62



Big news for surface mount designers.

Our P2824 Optoisolator/Photocoupler is ideal for tight spaces, specs and budgets. This subminiature molded component is engineered for easy surface mounting in many OEM designs.

Boasting a 1500 Vrms isolation voltage despite its compact size, the P2824 is already used in many Japanese VCR's, CD players, cassette recorders and computers. Manufactured by Hamamatsu, a world leader in photonic devices and detectors, this space-saving component is also a budget-saver.

For complete information, call 1-800-524-0504
1-201-231-0960 in New Jersey

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BRIDGEWATER, NJ 08807
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International Offices in Major Countries of Europe and Asia.

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CIRCLE NO 63

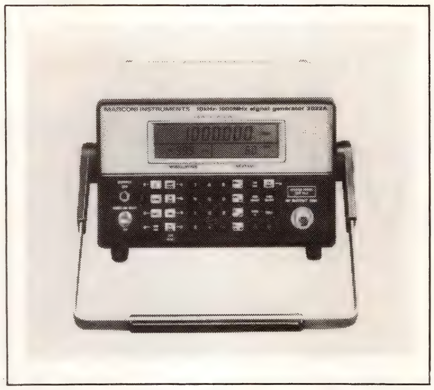
paged memory. The emulator provides four hardware breakpoints (for program or data) and you can logically combine complex conditions for each breakpoint, including the conditions of three external signal inputs. You can also daisy-chain as many as four emulators to emulate multiprocessor systems. Options for the emulator include a 64-channel, 256-word trace analyzer. Around $13,000.

Kontron Messtechnik GmbH, Oskar-von-Miller-Strasse 1, 8057 Eching, West Germany. Phone (08165) 77551. TLX 526719.

Circle No 429

Kontron Electronics Inc, 630 Clyde Ave, Mountain View, CA 94039. Phone (800) 227-8834; in CA, (415) 965-7020. TWX 910-378-5207.

Circle No 430



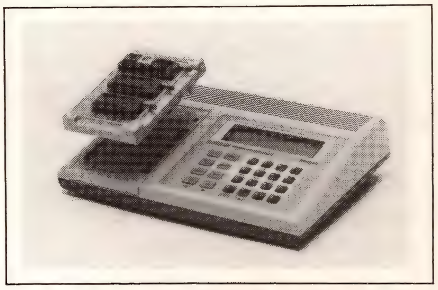
SIGNAL GENERATOR

- *Covers 10 kHz to 1 GHz*
- *Unit has 50Ω output*

The 2022A portable signal generator covers a 10-kHz to 1-GHz frequency range. You can set the output in 0.01-dB steps from −127 to +6 dBm (into 50Ω). The instrument's display shows seven different units. The residual FM is 7 Hz rms within a 300-Hz to 3-kHz bandwidth centered at 499 mHz. The AM frequency response is ±0.5 dB from 50 Hz to 15 kHz (with external 80% modulation). $4395.

Marconi Instruments, 3 Pearl Ct, Allendale, NJ 07401. Phone (201) 934-9050.

Circle No 431



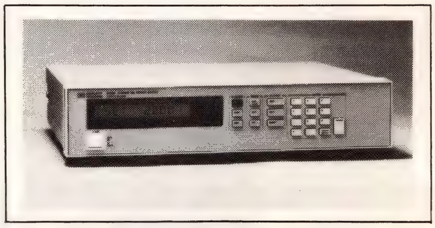
PROM PROGRAMMER

- *Unit programs PROMs, EPROMs, and EEPROMs*
- *Programs devices having capacities as large as 1M byte*

The SE4944 programs PROMs having capacities of 16k to 1M bytes. The unit executes fast-programming algorithms and comes with both Centronics and RS-232C interfaces. It interprets eight common data-transfer formats. The manufacturer offers optional socket adapters that let you use the programmer with different devices and package styles. The instrument accepts 90 to 250V ac input voltages. SE4944, including an R49441A adapter, $2000.

Epotek Corp, 2151 O'Toole Ave, Suite L, O'Toole Business Center, San Jose, CA 95131. Phone (800) 237-4590; in CA, (408) 922-0133.

Circle No 432



LAB SUPPLIES

- *Programmable supplies deliver 100W*
- *Rack-mount supplies are 4-quadrant units*

The HP 6632A, HP 6633A, and HP 6634A are programmable over the IEEE-488 bus. Each has a programmable, 4-quadrant power supply, a DVM, and a precision current shunt. Further, the IEEE-488 interface is built in. The output noise is 3 mV p-p, and the response time, no-load to full-load, is 15 msec. The fastest (and noisiest) programming speed is 400 µsec/voltage change. The units furnish 100W. The HP 6632A covers 0 to 20V; the HP 6633A, 0 to 50V; and the HP 6634A, 0 to 100V. Each model, $1500.

Hewlett-Packard Co, Inquiries Manager, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

Circle No 433

FREQUENCY COUNTER

- *Counter/timer covers dc to 120 MHz*
- *Unit performs count averaging*

The PM6665 timer/counter covers the frequency range from dc to 120 MHz. Its options include a built-in 1.1-GHz preselector, IEEE-488 programming, and a more accurate timebase. The unit has a 9-digit display and provides at least 7-digit resolution per 1-sec measurement interval. With averaging, the time resolution specs 20 psec. You can set trigger levels over the ±50V range. $895. Delivery, five weeks ARO.

Philips Test & Measuring Instruments Inc, 85 McKee Dr, Mahwah, NJ 07430. Phone (201) 529-3800.

Circle No 434

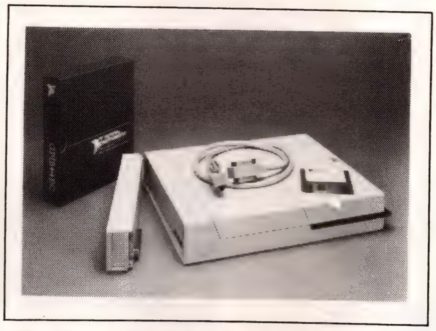
DVM/DMM CALIBRATORS

- *Calibrators adjust 8½- and 5½-digit meters*
- *Units are IEEE-488 programmable*

The Model 4707 and Model 4705 DVM/DMM calibrators check 8½- and 5½-digit meters, respectively, and are programmable over the IEEE-488 bus. The Model 4707 generates dc voltages as high as 200V (110V is optional) with 3-ppm accuracy (over 90 days). It also generates ac voltages, over a 200V range, at frequencies from 1 mHz to 10 Hz and with 80-ppm accuracy. The unit also supplies dc and ac currents. The Model 4705 provides similar outputs scaled for less accurate meters. For example, its dc-voltage accuracy is 16 ppm, and its ac-voltage accuracy is 300 ppm at as much as 100 kHz. Model 4705, $11,995; Model 4707, $17,495.

Datron Instruments, 4125 SW Martin Hwy, Stuart, FL 33497. Phone (305) 283-0935.

Circle No 435



GPIB CONTROLLER

- *Allows IBM lap-top computer to control IEEE-488 instruments*
- *Comes with device handler*

The GPIB-PC Conv assembly plugs into the rear of an IBM PC Convertible and provides an interface to the computer's I/O bus. The unit includes a DOS-loadable device driver, interfaces from the driver to several high-level languages, and a number of debugging and utility routines. The hardware/software package has full talker, listener, and controller functions. The unit can transfer DMA data at rates as high as 250k bytes/sec. $495.

National Instruments, 12109 Technology Blvd, Austin, TX 78727. Phone (800) 531-4742; in TX, (800) 433-3488. TLX 756737.

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Enclosure makers respond to system-packaging needs

Donna Coco, *Assistant Editor*

TECHNOLOGY UPDATE

CMOS the choice for multiplying D/A converters

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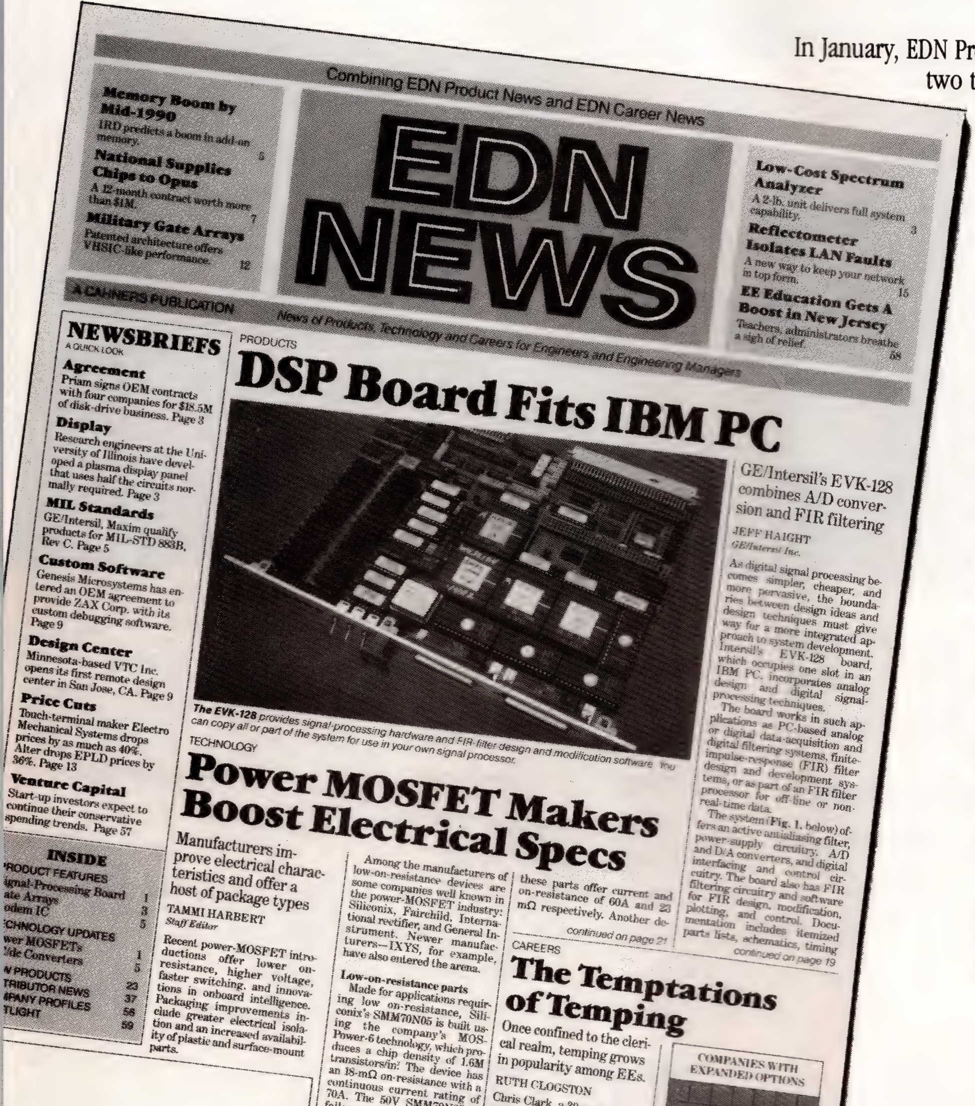

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Teachers, administrators breathe a sigh of relief. 58

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NEWSBRIEFS

A QUICK LOOK

Agreement
Priam signs OEM contracts with four companies for $18.5M of disk-drive business. Page 3

Display
Research engineers at the University of Illinois have developed a plasma display panel that uses half the circuits normally required. Page 3

MIL Standards
GE/Intersil, Maxim qualify products for MIL-STD 883B, Rev C. Page 5

Custom Software
Genesis Microsystems has entered an OEM agreement to provide ZAX Corp. with its custom debugging software. Page 9

Design Center
Minnesota-based VTC Inc. opens its first remote design center in San Jose, CA. Page 9

Price Cuts
Touch-terminal maker Electro Mechanical Systems drops prices by as much as 40%. Alter drops EPLD prices by 36%. Page 13

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PRODUCTS

DSP Board Fits IBM PC

The EVK-128 provides signal-processing hardware and FIR-filter design and modification software. You can copy all or part of the system for use in your own signal processor.

GE/Intersil's EVK-128 combines A/D conversion and FIR filtering

JEFF HAIGHT
GE/Intersil Inc.

As digital signal processing becomes simpler, cheaper, and more pervasive, the boundaries between design ideas and design techniques must give way for a more integrated approach to system development. Intersil's EVK-128 board, which occupies one slot in an IBM PC, incorporates analog design and digital signal-processing techniques.

The board works in such applications as PC-based analog or digital data-acquisition and digital filtering systems, finite-impulse-response (FIR) filter design and development systems, or as part of an FIR filter processor for off-line or non-real-time data.

The system (**Fig. 1**, below) offers an active antialiasing filter, power-supply circuitry, A/D and D/A converters, and digital interfacing and control circuitry. The board also has FIR filtering circuitry and software for FIR design, modification, plotting, and control. Documentation includes itemized parts lists, schematics, timing

continued on page 19

TECHNOLOGY

Power MOSFET Makers Boost Electrical Specs

Manufacturers improve electrical characteristics and offer a host of package types

TAMMI HARBERT
Staff Editor

Recent power-MOSFET introductions offer lower on-resistance, higher voltage, faster switching, and innovations in onboard intelligence. Packaging improvements include greater electrical isolation and an increased availability of plastic and surface-mount parts.

Among the manufacturers of low-on-resistance devices are some companies well known in the power-MOSFET industry: Siliconix, Fairchild, International rectifier, and General Instrument. Newer manufacturers—IXYS, for example, have also entered the arena.

Low-on-resistance parts

Made for applications requiring low on-resistance, Siliconix's SMM70N05 is built using the company's MOSPower-6 technology, which produces a chip density of 1.6M transistors/in². The device has an 18-mΩ on-resistance with a continuous current rating of 70A. The 50V SMM70N05, a follow-on to the company's SMP60N05 and SMM60N05, is available in TO-3 packaging for $10.11 (1000).

Like the SMM70N05, the SMP- and SMM60N05 are 50V MOSPower-6 devices. Unlike the newer device, however, these parts offer current and on-resistance of 60A and 23 mΩ respectively. Another de-

continued on page 21

CAREERS

The Temptations of Temping

Once confined to the clerical realm, temping grows in popularity among EEs.

RUTH CLOGSTON

Chris Clark, a 30-year-old programming consultant from Hopkinton, MA, has worked as a contractor for six months. He started temping because he wanted freedom and independence—he is developing his own software and needs to avoid the conflicts of interest

continued on page 58

COMPANIES WITH EXPANDED OPTIONS

EEs are increasingly being drawn toward temping

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In a separate section, EDN News will keep you abreast of professional developments and job openings in the electronics field. It will carry editorial aimed at your career and professional growth. Editorial that will help you find a job and keep it.

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EDN News. Hot News of Products, Technology, and Careers

EDN NEWS

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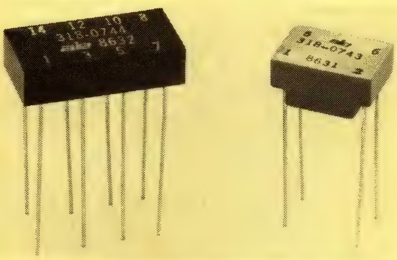

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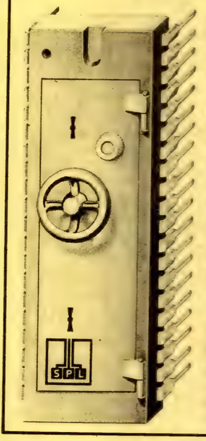

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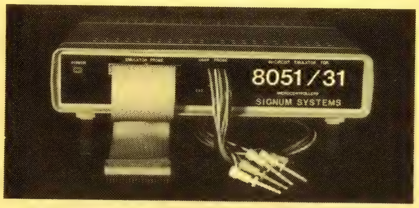

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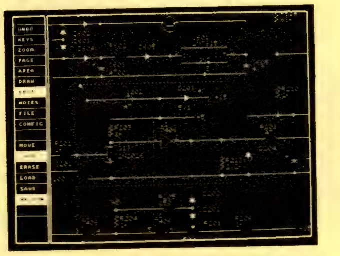

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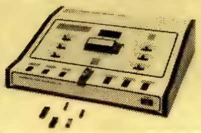

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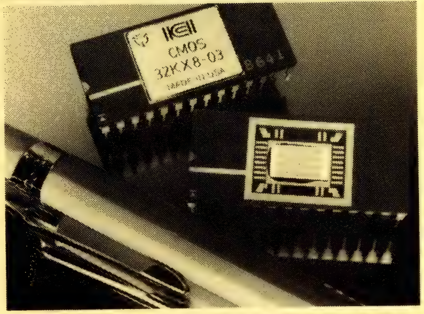

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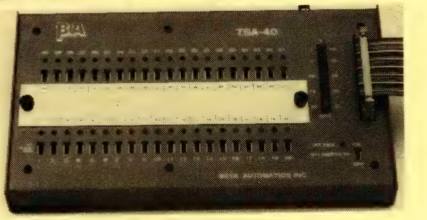

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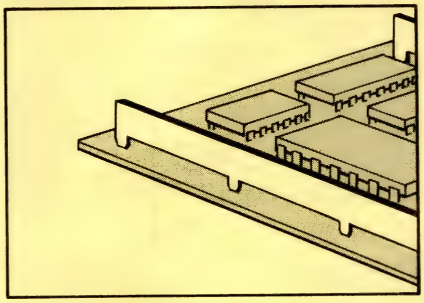

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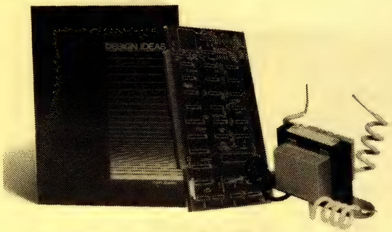

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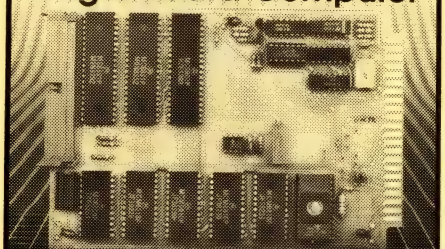

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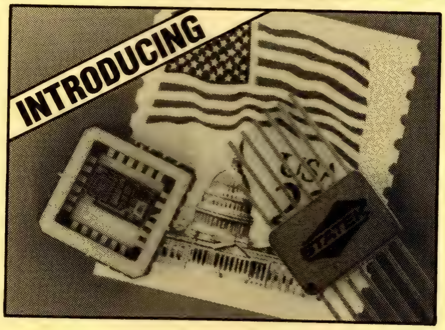

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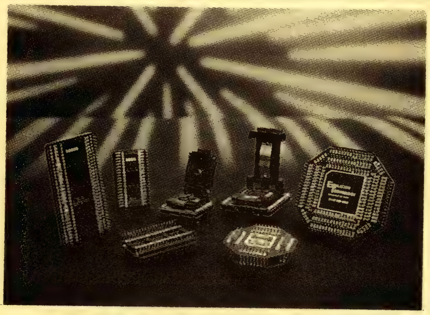

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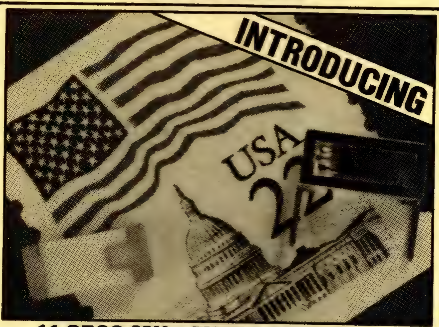

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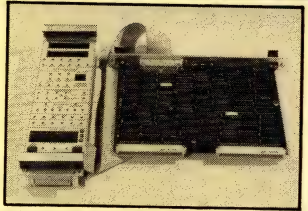

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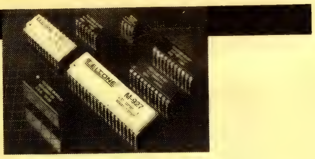

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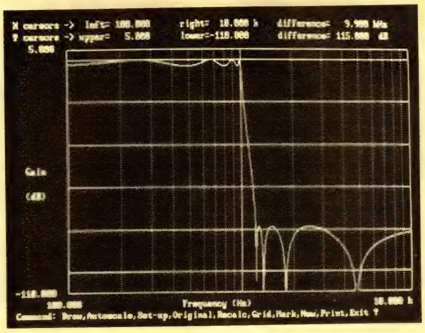
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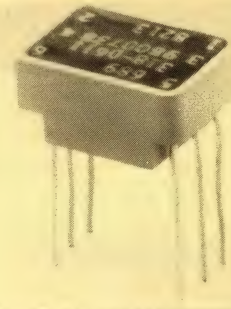

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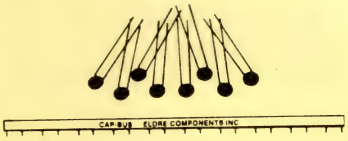

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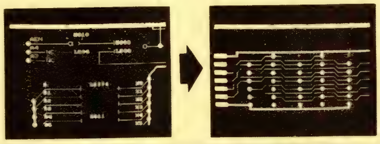

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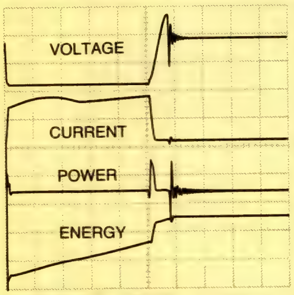

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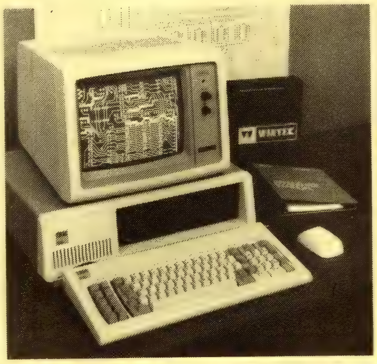

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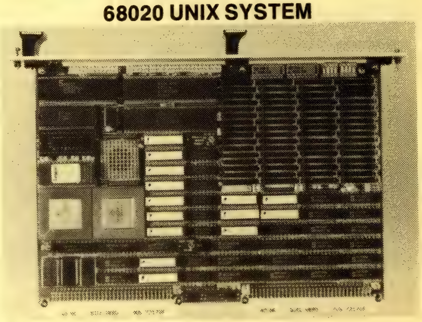

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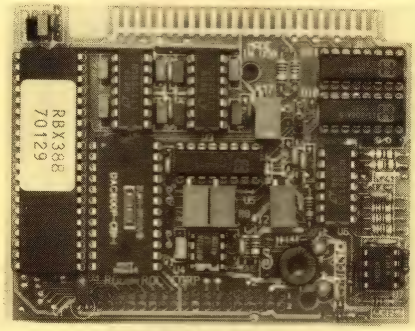

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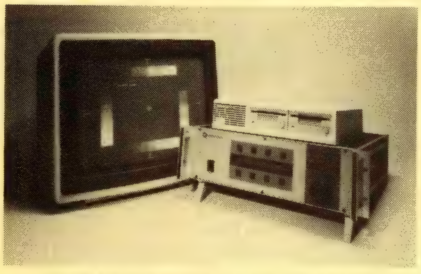

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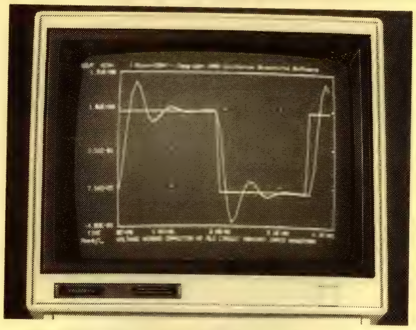

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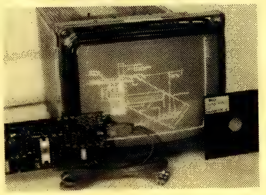

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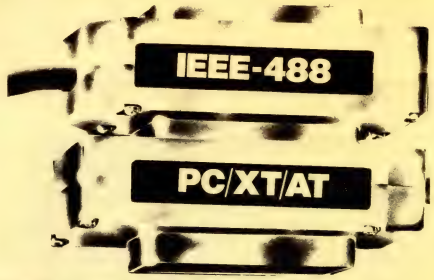

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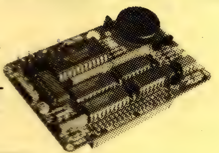

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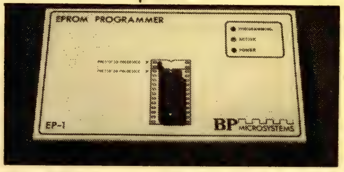

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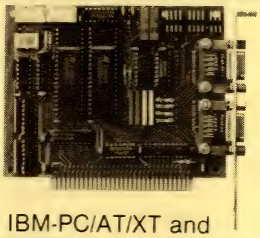

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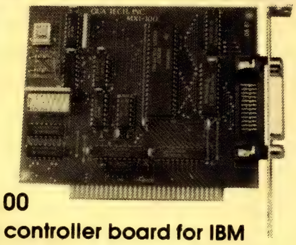

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Handbook describes Instrument applications

Application Note 349 describes 10 applications of the PC Instrument module family. Each section provides an application background, a circuit description, block diagrams, schematics, a test description, a program description, and a sample program. The topics covered include the development of a programmable current source, semiconductor tests, optocoupler tests, and the measurement of power-transistor switching losses.

Hewlett Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303.

Circle No 410

Newsletter covers fiber-optic testing

The Winter 1987 issue of *Fotec Fiber Optic Testing News* presents information on fiber-optic network safety and HeNe laser sources for visual fault finding. It includes articles on the recent efforts by the US government to standardize one multimode fiber type and a report on work done at Bell Communications Research on potential errors in testing single-mode fibers.

Fotec Inc, The Schrafft Center, 529 Main St, Boston, MA 02129.

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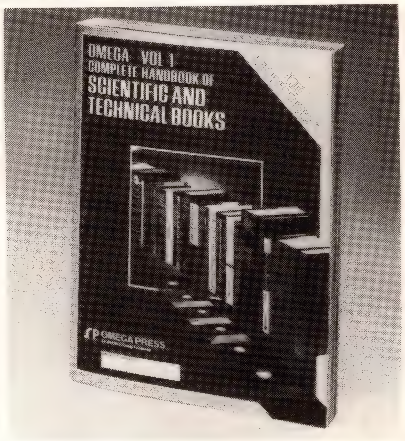

Catalog lists scientific and technical books

The *Complete Handbook of Scientific and Technical Books* provides descriptions of more than 10,000 scientific and technical English-language texts from 14 publishers. The listing includes books in 16 subject areas, including engineering, the physical sciences, mathematics, and computer science. It's organized according

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Circle No 412

Book lists data-control and -acquisition boards

In addition to data-acquisition and -control plug-in boards, this 145-pg 4-color catalog lists industrial-control and monitoring boards. The handbook is divided into three sections: plug-in boards (including software) for the IBM PC/XT, PC/AT, and compatibles; MetraBus industrial I/O devices for IBM PC/XT, PC/AT, and VME Bus computers; and signal-conditioning modules. It introduces several new products.

MetraByte Corp, 440 Myles Standish Blvd, Taunton, MA 02780.

Circle No 413

Booklet reviews IEEE-583 and IEEE-960 tools

A comprehensive review of Camac (IEEE-583) and Fastbus (IEEE-960) devices is presented in *Standardized Tools for Data Acquisition and Control 1986-1987*. The 40-pg booklet divides more than 150 automation products into four sections. The first section describes powered Camac crates with housing capacities for large and small applications. The second section highlights Camac interfaces, such as Ethernet, VAX-BI, Q Bus, Unibus, and the IBM PC bus. The third section presents system configurations and the PC/DBS (process control/database system) software package, as well as Camac handlers and drivers. The final section summarizes over 20 Fastbus products.

KineticSystems Corp, 11 Maryknoll Dr, Lockport, IL 60441.

Circle No 414

App note presents microwave test applications

Application Note FT3 describes microwave test applications of the company's closed-loop YIG tracking filters. Chapters cover methods of improving the measurement of filter rejection; gain compression testing of amplifiers; extending the dynamic range of spectrum analyzers; mixer and converter conversion loss; and oscillator noise and spurious re-

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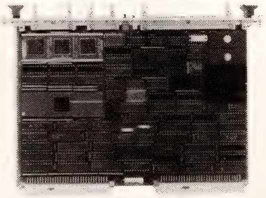

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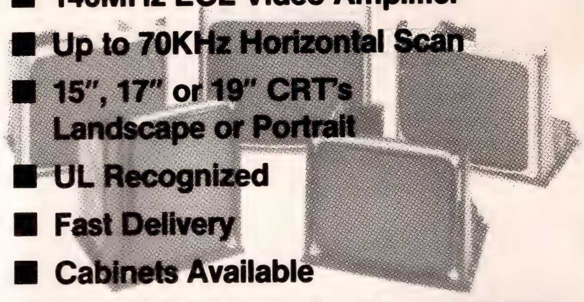

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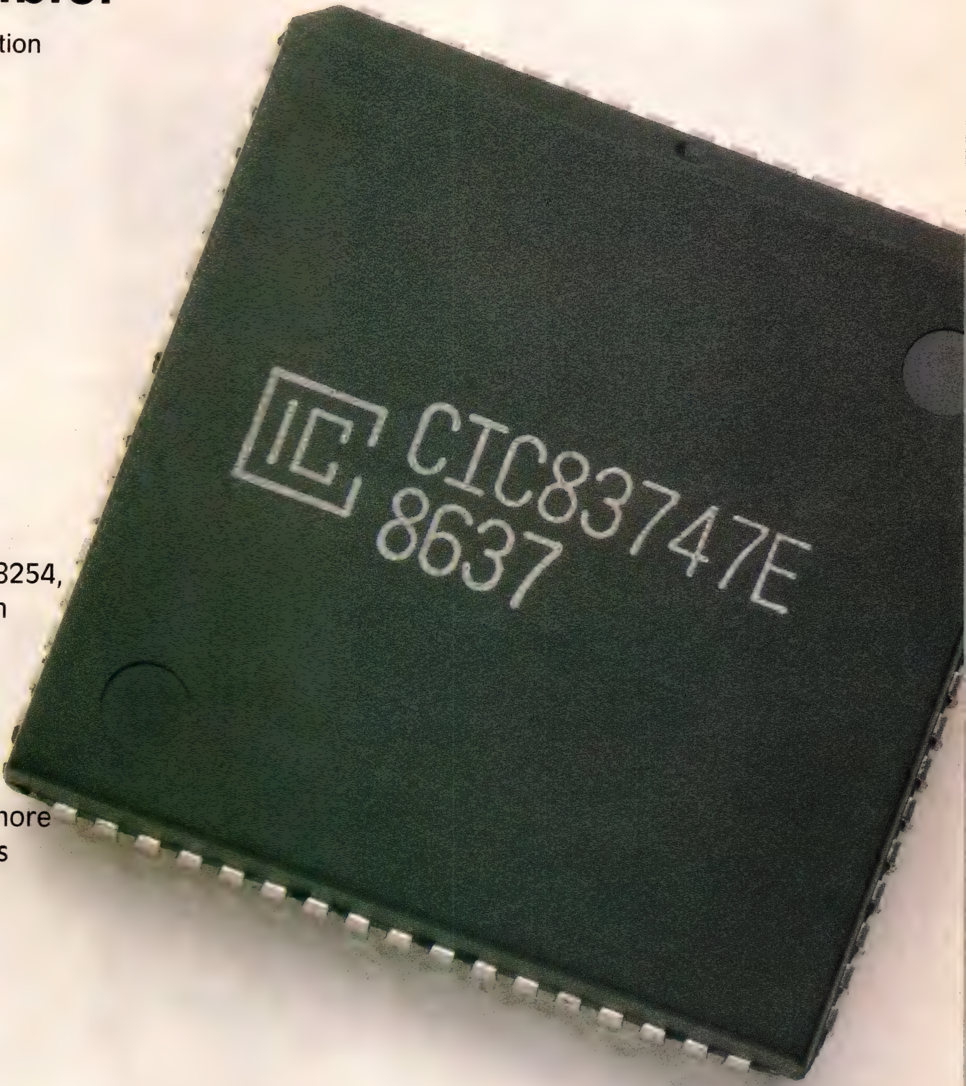

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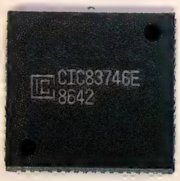

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CIRCLE NO 207

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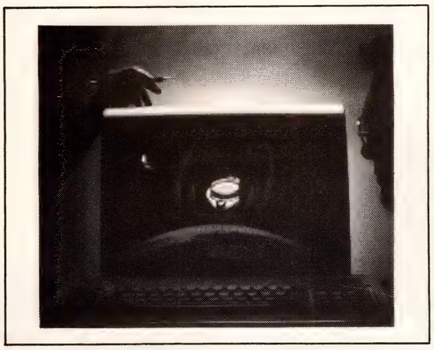
sponses. The note also contains application hints, diagrams, and schematics.

Ferretec Inc, 544 Gibraltar Dr, Milpitas, CA 95035.

Circle No 415



Heat sink catalog

This heat sink catalog has been rewritten and expanded to include 20 new stamped heat-sink designs. More than 250 extruded heat-sink profiles have also been added. Six pages of the publication provide information on labor-saving options such as Thermalclips.

Thermalloy Inc, Box 810839, Dallas, TX 75381.

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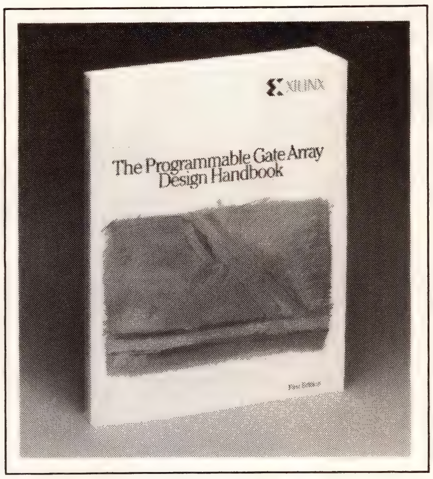

Handbook aids in design of CMOS gate arrays

The Programmable Gate Array Design Handbook is available to system designers who are interested in CMOS user-programmable gate arrays and development systems. The 288-pg book explains how to implement designs using the company's programmable gate arrays and how to reduce design time. It includes a listing of design examples.

Xilinx Inc, 2069 Hamilton Ave, San Jose, CA 95125.

Circle No 417

Brochure features electronic and industrial test equipment

The March 1987 issue of the bimonthly catalog *Metric Mart* provides a listing of equipment for electronic testing, industrial test/measurement, and telecommunications testing, as well as microprocessor development systems and desktop computers/controllers. The 35-pg catalog's table of contents is alphabetically arranged and highlights items such as best buys,

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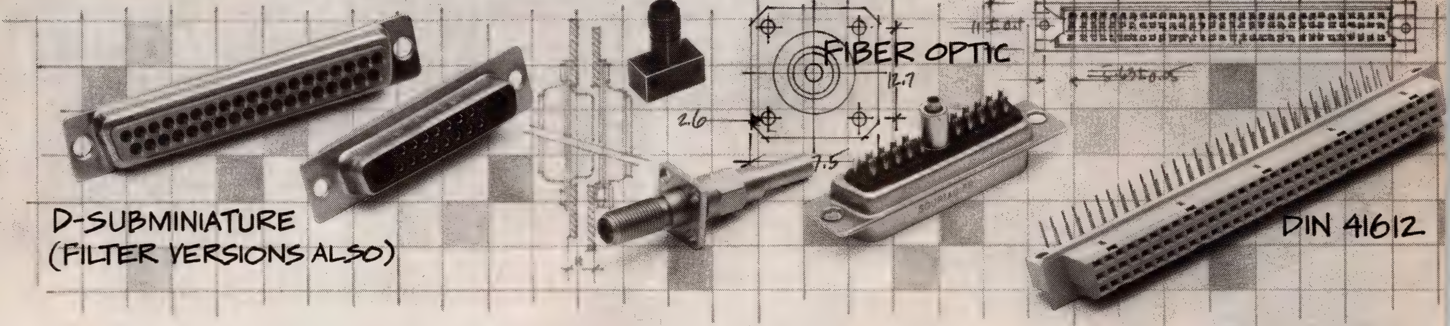

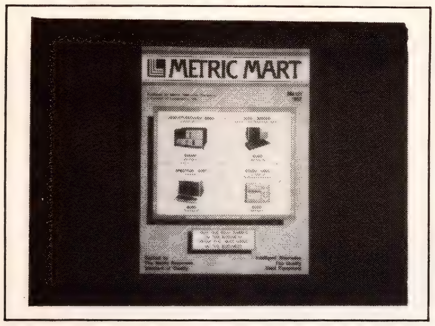
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Metric Resources Co, 9246 Gaither Rd, Gaithersburg, MD 20877.

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Article outlines digital-recorder systems

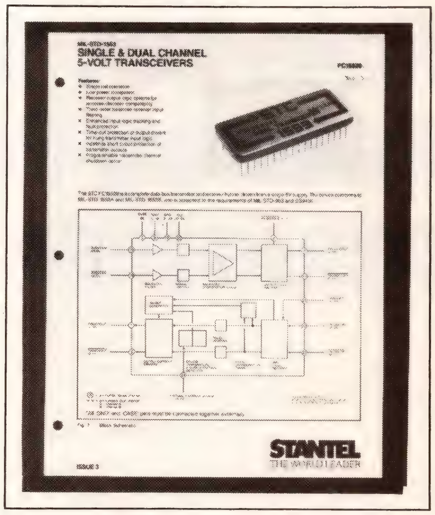
This 3-pg technical paper, *High Density Digital Recorders in Ground Stations*, discusses how you can use a high-density digital recording (HDDR) system to make a tape of data generated by earth-observing satellites. The topics discussed include 3-position code, bidirectional record and reproduction capability, bit-error-rate performance, error detection and correction, and autoranging bit synchronization. The paper also describes applications such as the company's EMI HDDR systems for NASA's Spacelab program and the European Space Agency's ERS-1 satellite project.

Thorn EMI Technology Inc, 8601 Dunwoody Pl, Atlanta, GA 30338.

Circle No 419

Coverage of 5V-only transceivers

This 10-pg brochure describes a line of MIL-STD-1553 single- and dual-channel 5V-only transceivers. It covers receiver specifications; transmitter specifications and input decoding power; thermal, supply-current, mechanical, and MIL-STD-883C quality-conformance data; recommended operating conditions; and resultant electrical characteristics. It also provides five schematics.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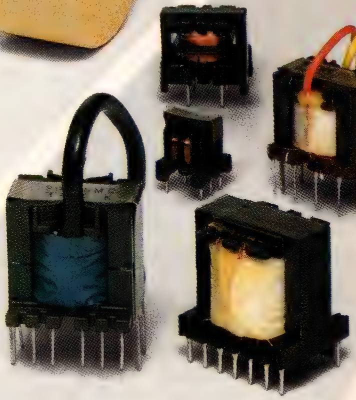

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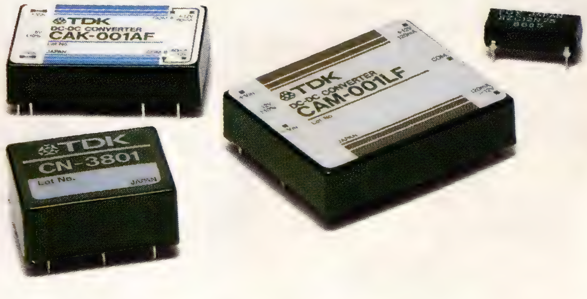

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CIRCLE NO 208

Taking aim at engineers' documentation woes

Deborah Asbrand, *Associate Editor*

When Charlie Sorgie worked as a software consultant for Raytheon in the middle 1970s, the typewritten pages that formed the documentation for the operating system he was designing eventually became so caked with white correction fluid that they would no longer slip smoothly through his department's photocopier.

"I like to do a lot of up-front design, and I had this document laughing at me," Sorgie recalls. "I couldn't control it." Eventually, the maintenance of the documentation's growing number of pages became as much of a challenge as the design on which he was working.

Yet Sorgie may have the last laugh. As chief scientist at Context Corp, a one-year-old spin-off of CAE-workstation maker Mentor Graphics, he supervises the development of workstations that let engineers electronically generate design documentation with integrated text and graphics, tables of contents, references, numbered sections, and indexes.

Rather than consider documentation as a loathsome chore, Sorgie and his engineering colleagues view it as an integral part of the design process. Their goal is to design automated tools that render documentation as fluid a process as design, and as a result, produce documents worth having. Says Sorgie: "If an engineer is trying to document a design, and he's given tools that don't support the changes he has to make, then the documentation gets out of date, or the engineer spends too much time on it, or it becomes too vague to be of use."

At Context's headquarters in Beaverton, OR, there is no shortage of anecdotes on how outmoded documentation tools complicate the design process. Greg Lloyd, a member of the company's technical staff, spent most of his two-year stint in the army as an engineering aide in the Washington, DC, office of the commanding general of the Safeguard missile project. There he worked on status reports and verification and validation of project documentation. Much of Lloyd's time was occupied using the projects' thousands of documents stored in six file cabinets near his desk.

As a product-marketing representative at Hewlett Packard in the early 1970s, Michael Bosworth, now Context's president, found such a paucity of tools for engineering documentation that he resorted to purchasing an expensive electronic page-composition system designed for newspapers and magazines.

Although electronic publishing had mushroomed to become a multibillion dollar market—$3.5 billion in 1985—few companies had designed products targeted for engineering documentation. Sophisticated editing systems eased the jobs of technical writers, but design engineers were still using antiquated, manual methods of updating and revising design documents. The result was a communication bottleneck between engineering and technical-publishing departments.

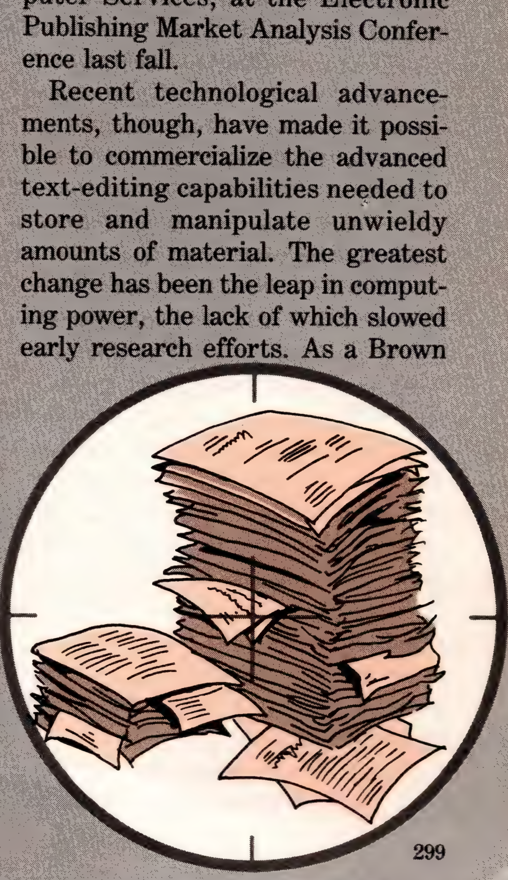
Government paperwork

The greatest number of documentation entanglements are found in the government sector. Military and defense projects require volumes of documents that detail not only the evolution of the project's design, but also precise information on parts numbers and prices, including such particulars as the site of the warehouse from which the parts were shipped and the name of the freight carrier that transported them from storage. Almost no information is too trivial to be part of the "audit trail."

Such explicit record keeping produces a logistical nightmare for the engineers who must not only detail the design and its parts, but also keep track of the innumerable sections and revisions of each document. According to the IEEE's 1985 US Member Opinion Survey, defense-industry engineers report that 32% of their time is spent on clerical tasks. Worse, only 34% say that the paperwork helped them in their work in any way.

The problems caused by the mountains of technical documents spread to other departments as well, and the high costs incurred by companies may be an important factor in spurring management to find solutions. "With the industry cost of military publications approaching $1000 a page, it's imperative that we do everything to control that cost," said Robert Sarkies, manager of publishing systems for Boeing Computer Services, at the Electronic Publishing Market Analysis Conference last fall.

Recent technological advancements, though, have made it possible to commercialize the advanced text-editing capabilities needed to store and manipulate unwieldy amounts of material. The greatest change has been the leap in computing power, the lack of which slowed early research efforts. As a Brown



University undergraduate in 1968, Lloyd worked on documentation research sponsored by IBM and the National Science Foundation, but had to wait until after midnight to run the system; at any earlier hour when the system was under heavy use, its power-eating requirements would have overtaxed the 512k bytes of core memory in the IBM System/360-50 mainframe on which it ran.

Engineering workstations now typically offer 4M to 8M bytes of memory, more than enough to accommodate comfortably the documentation system's needs. Moreover, the increasing availability—and steadily dropping prices—of such machines makes using them for documentation more palatable to companies. "When workstations cost $75,000 to $80,000, no one wanted to tie them up with documentation programs," says Andy Rappaport, president of The Technology Research Group, a Boston, MA, market-research firm. "That attitude is changing as the costs come down."

Still, the idea of providing engineers with sophisticated tools with which to automate documentation is one that grates on some managers, says Sorgie. "Managers want engineers to design, not document," he says. "There are still managers who think that documentation is just writing down what you know."

Documentation is a much more interactive, team process, Sorgie claims. Automated documentation tools are a way to manage not only paper but also change, a quality inherent in design. Yet the productivity gains from such tools are not always tangible, Sorgie says. "It's difficult to gauge how much better a product is because the documentation revision process has gone smoother," he says. "Indexing, for example, is very helpful in a document, yet it is by no means worth doing by hand."

Lloyd's ideas about documentation, too, go beyond the design of the company's products. His view that automating the paperwork of engineering will free engineers for more design and analysis is an extension of his belief that the computer is likely to be "the ultimate means of organizing, structuring, and presenting information to enhance people's capabilities to deal with abstract, complex issues." This viewpoint, he admits, is "very different from looking at computers as a way to send out credit-card bills."

Sophisticated editing systems eased the jobs of technical writers, but design engineers were still using antiquated, manual methods of revising design documents.

Armed with the knowledge of how unwieldy documentation whittled away at a designer's time, Sorgie designed his first small documentation system in the late 1970s. He later developed a similar system for Tektronix's 4050 Series of personal computers. Sorgie left Tektronix in 1981 to become one of Mentor Graphics' founding engineers. There he put to use his accumulated knowledge of documentation systems to produce Doc, the text editor and formatter that Mentor began bundling in its CAE workstations in 1983. His goal was to design a self-maintained system that would free engineers to concentrate on the system's content. "I designed the system that I would have wanted to have as an engineer," he says.

In 1986, when Mentor Graphics decided to spin off a new company to concentrate on documentation workstations, Sorgie joined Context and became architect of its documentation systems. The company's first-generation products let users manipulate integrated text and graphics and generate tables.

Potential customers initially viewed the company's products with skepticism. A frequently asked question, Lloyd remembers, was "Is there anything you can do to documents other than to treat them as word-processing documents that expedite the engineering task?" Many were unfamiliar with the view that documentation is as evolutionary an aspect of engineering as is design.

In their latest product, Context's engineers have taken on the problem of engineering control orders and have devised a system whereby engineers can implement design and parts changes and can propagate those changes to all related documents. The system's windowing capabilities lets a user examine a document on one screen while another screen details the revisions specified by other project members. Users can call up any revision of a document and, through colored bars that highlight changed portions, observe the modifications made to the document and which project member made them. All section numbers, references, tables of contents, lists of illustrations, and indexes are updated as changes are made.

One customer, having viewed a demonstration of the change-control tools, says it may take time for the advantages of such advanced capabilities to become clear. "The tool is so innovative in the way they've implemented it in the workstation environment that it's going to take a while for us to realize what we've got," he says.

Sorgie sees irony in the long period of time it has taken engineers to get around to easing their own productivity bottlenecks. "Engineers in the electronics area had designed a lot of solutions, but not one to help themselves," he says. **EDN**

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EDN

Issue Date	Recruitment Deadline	Editorial Emphasis
June 25	June 4	ASIC (Semicustom ICs) Directory; Analog ICs; Surface-Mount Technology
July 9	June 18	Product Showcase-Volume 1; ICs & Semiconductors; Software
July 23	July 2	Product Showcase-Volume II; Computers & Peripherals; Test & Measurement Instruments
Aug. 6	July 16	Computer Boards; Digital Signal Processing; Test & Measurement; Top Ten Reader Vote Contest
Aug. 20	July 30	Military Electronics Special Issue; Fiberoptics; Software
Sept. 3	Aug. 13	Analog ICs; CAE; ASICs
Sept. 17	Aug. 27	Memory Technology; Communications Technology; Software
Oct. 1	Sept. 10	Surface-Mount Technology; Computers & Peripherals; Industrial Product Showcase
Oct. 15	Sept. 24	Test & Measurement Special Issue; Analog ICs; ASICs

EDN News

Closing: May 28
Mailing: June 18

Closing: June 25
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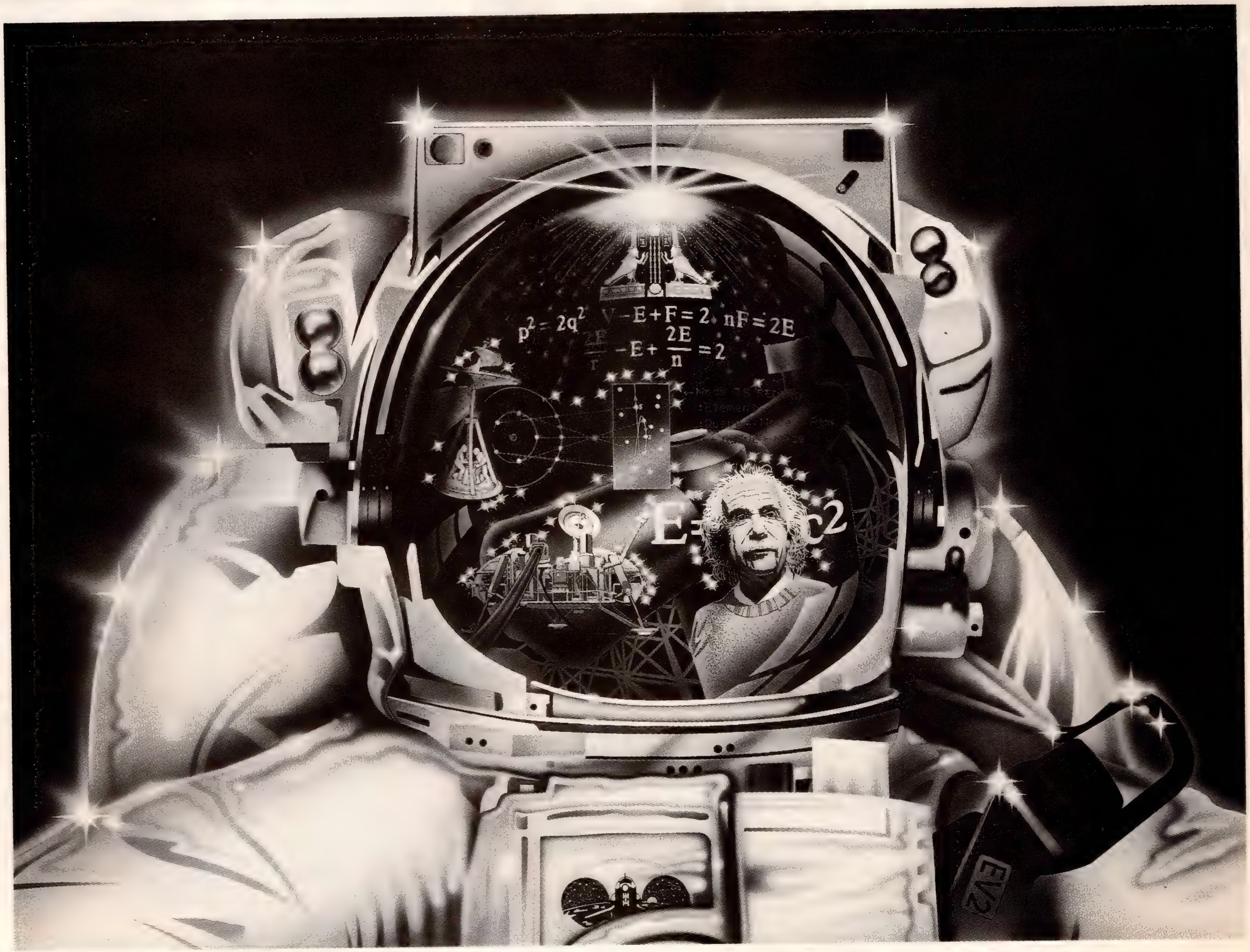

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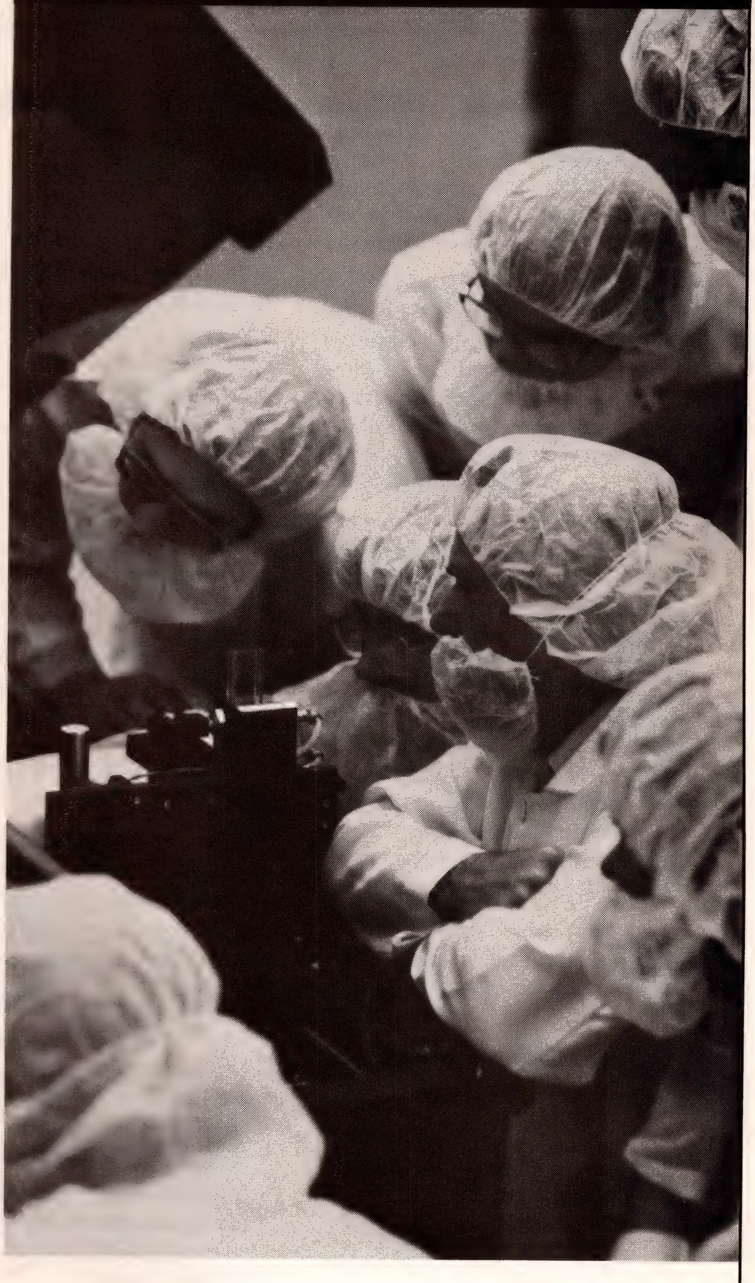

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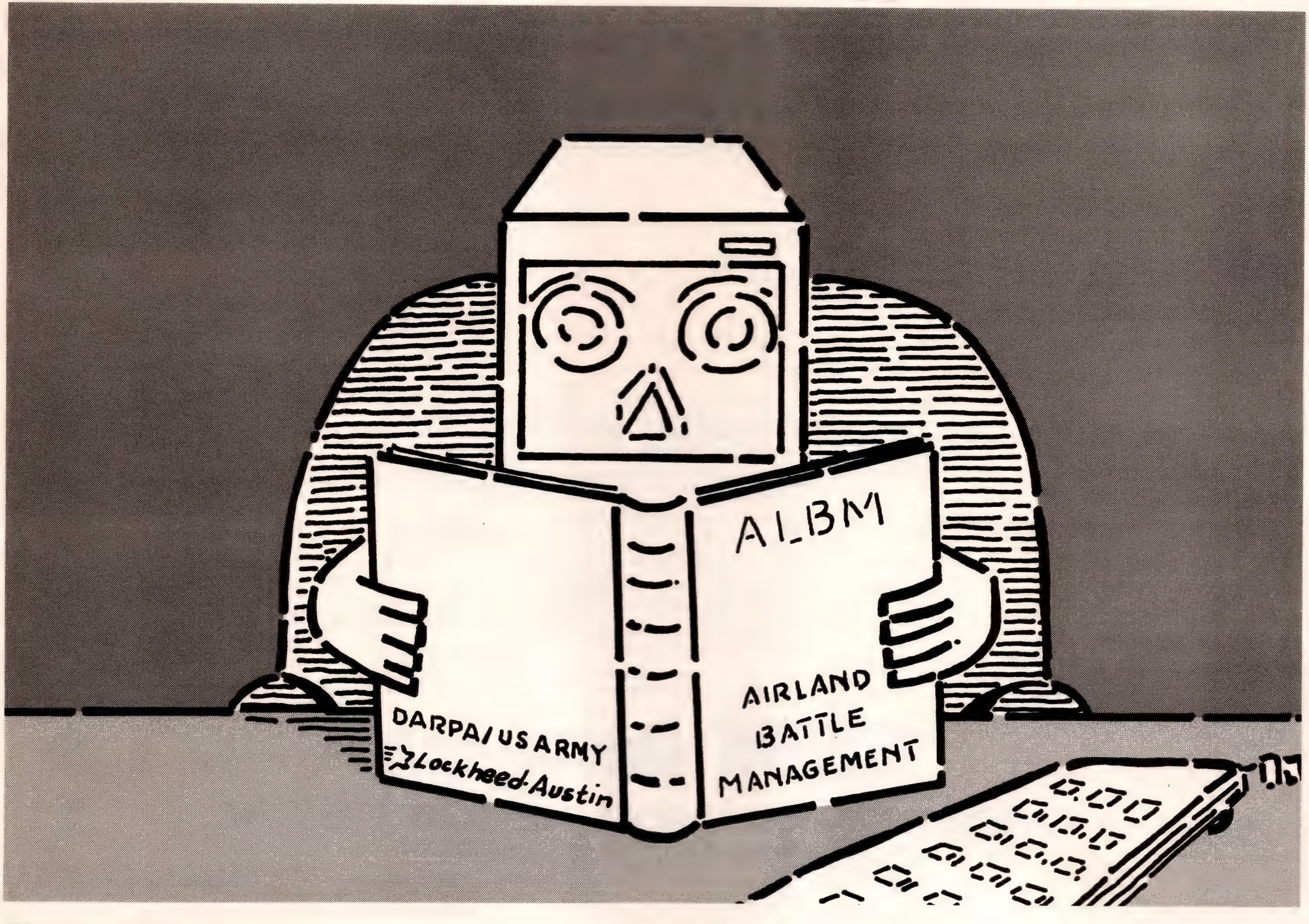

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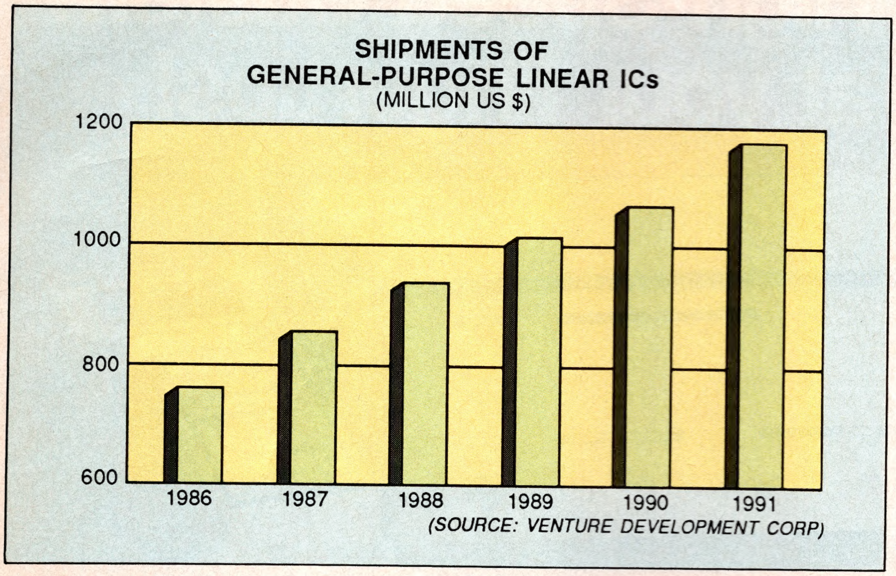
LOOKING AHEAD

EDITED BY GEORGE STUBBS


SHIPMENTS OF GENERAL-PURPOSE LINEAR ICs (MILLION US $)

(SOURCE: VENTURE DEVELOPMENT CORP)

High-performance op amps to boost linear-IC demand

Despite the mixed fortunes of the electronics industry in recent years, and despite the increased use of digital components and application-specific ICs, the demand for general-purpose linear ICs has remained high. Growth in this market will continue through the remainder of the decade, says the market-research concern Venture Development Corp (Natick, MA). Total shipments of operational amplifiers, instrumentation and isolation amplifiers, voltage references, comparators, computational circuits, and analog switches and multiplexers will increase at an 8.7% average annual rate through 1991. The total value of shipments in that year will be $1.2 billion.

Operational amplifiers constitute the largest share of this market, measured in 1986 shipments, and demand for these devices will grow at a faster rate than demand for any other type of general-purpose linear IC. According to VDC market analyst James K Brown, makers of military systems, test and measurement equipment, and industrial-control systems will shift demand toward higher-performance operational amplifiers, so dollar values of shipments will grow at greater rates than the number of units sold.

Another popular type of linear IC, voltage references, will see steady growth through the remainder of the decade. VDC believes that the integration of voltage references into more complex ICs will not have a great impact on growth in demand. The incorporation of voltage references into data converters has already occurred, says VDC, and will not further depress the demand for reference ICs. Bandgap and zener-based types will be the dominant voltage references.

One type of general-purpose linear IC that will experience growth rates approaching those of op amps will be comparators. The need for faster devices will drive growth rates in this area. Both the manufacturers and the specifiers of comparators identify response time as the most important parameter. Designers of military and other systems that need response times faster than 10 nsec are pressing the case for even faster devices.

Sensor/transducer market will approach $7B by 1995

The market for solid-state sensors and transducers is expected to grow from a 1985 market of about $2.8 billion to more than $6.9 billion in 1995, reports the Market Intelligence Research Co of Palo Alto, CA. Average annual growth rates will fluctuate between 8 and 11% during that period. US sales of the devices are expected to account for nearly half of the total world market ($3.2 billion in 1995).

Of the wide variety of devices that make up the market, solid-state image sensors, diffused-semiconductor pressure sensors and transducers, and accelerometers should show the highest growth rates, topping 10% annually to 1995. Advances in the manufacturing of all types of sensors and transducers include micro-machining, which was essential to the development of IC sensors and is now being used to create "smart" devices.

A $2.8B 1987 market seen for computer security

The market-research company International Resource Development Inc (Norwalk, CT) projects that the US market for computer-security products and services will reach or exceed $2.8 billion in 1987, a figure that represents a 700% increase over the 1982 market. Even so, the development of the market has been "significantly short of its real potential," says IRD analyst Jean Buffham.

According to Buffham, managers of large corporate data-processing departments are routinely taking "hair-raising risks" with their facilities, through neglect of backup and security provisions. Moreover, says Buffham, commercial data-processing departments have "failed to take encryption seriously. Lack of encryption in corporate data networks, coupled with little or no attention paid to spurious electromagnetic emissions, means that 'tapping' corporate data networks has become quite easy."

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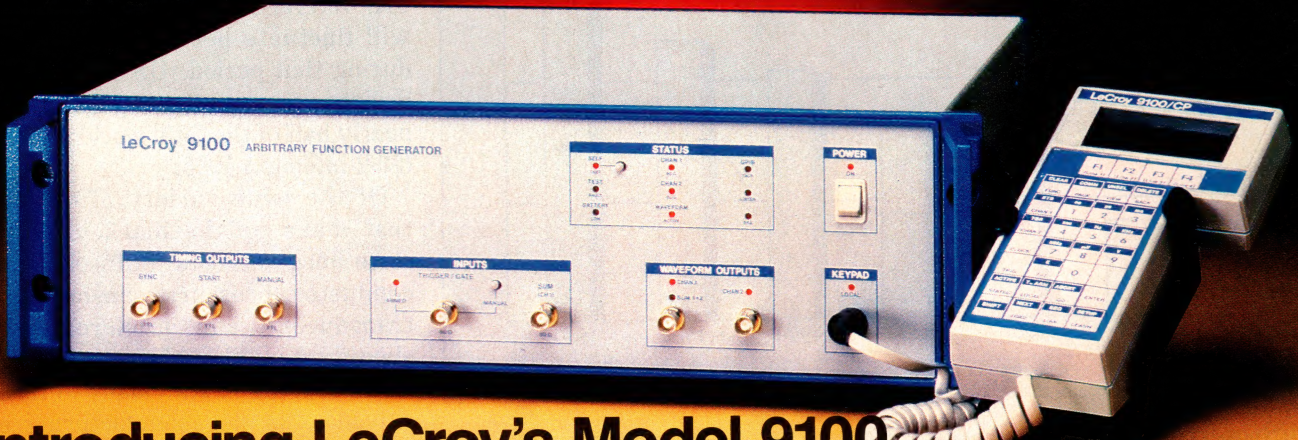

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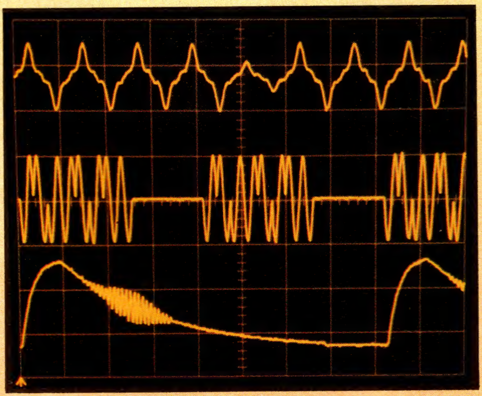

"Real World "Waveforms: Disk Head (top), PSK ASC II "k" (middle) Flourescence Decay (bottom)

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Creating new waveforms is easy with LeCroy's Optional EASYWAVE™ software package designed for use with the IBM PC™ and most compatibles. Simply select some basic shapes from a library, add them together, and then stretch them to the amplitude and time duration that you desire. Or acquire "real world" waveforms with LeCroy digitizers and digital oscilloscopes.

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Universal Data Systems, the company that developed the first 9600 bps dial-up modem, has now applied its special brand of craftsmanship to the CCITT V.32 specification.

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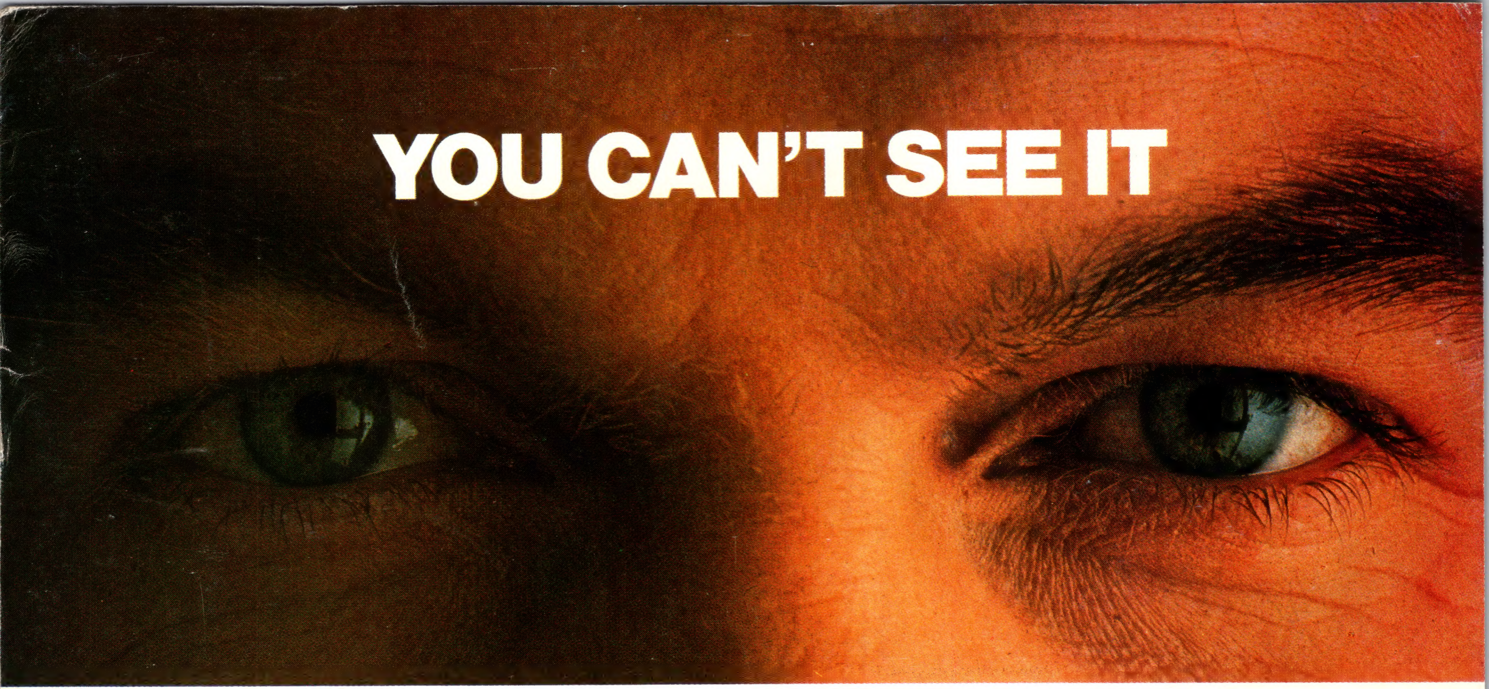

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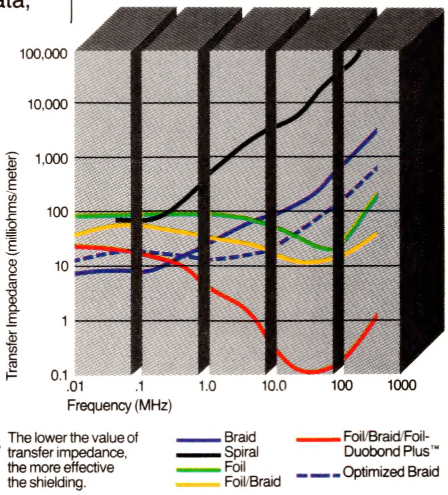

Test Methods Protect Your System
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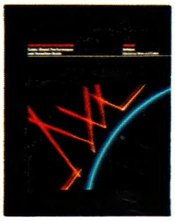

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